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GEORG ELIAS MÜLLER

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G. E. Müller was born in Grimma, Saxony, on July 20, 1850. He studied at the universities of Leipzig, Berlin, and Göttingen; in 1873 he obtained his degree of Ph.D. at Göttingen and in 1876 became a Privatdozent. Whilst at Czernowitz, where he was professor for one year, he was invited to return to Göttingen as the successor of Lotze. At this university he occupied the chair of psychology for 40 years until his retirement in 1921. Even then this Nestor of psychology lived to devote 12 more happy years to scholarship of the most intensive kind, and on December 23, 1934, blessed with amazing mental vigor and freshness almost to the end, he died at the age of eighty-four.

Müller's name is inseparably bound up with the history of experimental psychology, and to estimate his life's work would be neither more nor less than to describe the efforts which have been made to apply the methods of natural science to the field of psychology.

The attention of Lotze had early been drawn to Müller's unusually acute and independent powers of criticism, which he had displayed even as a student when he first propounded his "Lokalzeichentheorie". His powers of analysis and penetration were freely and unenviously acknowledged by another of the great founders of modern psychology—no other than G. Th. Fechner, who even undertook a thorough revision of his book on psycho-physics as a result of Müller's criticism.

Early in his career Müller developed a passion for methodology, and became the recognized authority on method in experimental psychology. His individuality of thought is no doubt responsible for his having chosen such austere subjects as he did for special study;

but on the whole it is true that psychology, in its struggle for recognition as an exact science, owes a great deal to Müller.

Müller only came to actual experimental work after the foundation of the Psychological Institute in Göttingen in 1891. He then devoted himself to three main fields of inquiry, namely psycho-physics, problems of vision, and memory. Since the days of Weber and Fechner experiments in weight-lifting had provided the classic material for psycho-physical method. So too in Göttingen, the subjects were zealously made to compare weights. Experiments in weight-lifting may serve as a starting-point for fruitful considerations in relation to the central problem of the building-up of our bodily ego, but that was not the purpose in the minds of psycho-physicists in those days when they carried out their weight-lifting experiments. The experimental material as such restricted them but little; it was merely the raw material for methodological conclusions, and any other would have served equally well. Are we to assume then, that their investigations have lost their interest? It would indeed be a matter for regret if those records no longer found readers among the students of experimental psychology, for the method-technique which they set forth is of imperishable value.

In his studies in memory Müller took as his basis the classical work by Ebbinghaus. Here Müller had in mind the establishment of a "Vorstellungsmechanik" on a sound empirical foundation, and while in pursuit of this he made a great many discoveries which in my opinion must not only be accounted among the permanent assets of classical association-psychology, but will always claim a high place in the psychology of the future, whatever its trend may be.

I think I may say that Müller was at heart most deeply interested in the investigation of problems of vision. It is strange and paradoxical how many of the German physiologists and psychologists who were drawn to enquire into problems of color had, like Müller, an abnormal sense of color. Müller's first objective was to reconcile the two theories of color set up by Helmholtz and Hering. But he soon realized how inadequate these theories were for the explanation of the amazing complexities of color-perception. It would be no exaggeration to say that no one has had a wider knowledge of the pure facts relating to this question than Müller.

Müller's lectures dealt with general psychology as well as those special aspects which formed the subjects of his published works, namely psycho-physics, problems of color, and memory. It is possible that he was the last lecturer in any German university to deliver

a special course of three-hour lectures on psycho-physics, and indeed very few could have held forth on such a dry subject with so much force and impressiveness. Müller never conducted a seminar for the purpose of discussion; I believe that this had its roots in the fact that he hated improvisation in any form.

He always maintained personal contact with the pupils working under him. He accustomed them to the most meticulous working-methods, and it was of no small importance in this matter that Müller himself served as a subject in every single investigation. Scientific work was in Müller's view more a question of duty than of personal inclination. In fact, the conception of duty had taken complete possession of this great scholar. Only thus can we explain the mass of work which he exacted from himself, though for years and years his body was almost exhausted through insomnia.

If for twenty years Müller directed the activities of the Gesellschaft für experimentelle Psychologie, for the foundation of which he himself was chiefly responsible, it was not so much due to his outstanding organizing powers, as to the fact that boundless confidence was felt in the impartiality of his mind and thought.

In scientific as well as in social affairs Müller had a mania for impartiality, and his strong sense of its importance could make him seem hard even to students who had close personal contact with him. Yet his sense of justice caused him to take up the cudgels on behalf of persons whom he thought had been unjustly injured; they always found in him a champion filled with unusual courage. He was always ready to acknowledge the achievements of others; envy was foreign to his nature. Nor had he the slightest trace of that other human weakness—vanity. He must have been pleased at the many academic honors which were conferred upon him. He was a M.D.h.c. of Leipzig, honorary Ph.D. of Frankfurt University, and honorary member of numerous learned societies. But he associated them with his work and not with his person. He cared nothing for outward honors. I remember one morning when he was to be invested with a high order by the "Kurator" of the University, on the occasion of his nomination as a "Geheimrat". On returning home he forgot to take the decoration with him, and we had to run after him with it.

Müller possessed a gift which is tending more and more to disappear from society: he was a good listener. When new hopes and ventures were being described to him, one could be sure of an interested and sympathetic hearing. To my own knowledge this capacity

for intelligent listening which he displayed proved a great encouragement to many colleagues who used to visit him.

Müller showed a profound mistrust of those who wore the cloak of cheap and futile idealism. He could find hard words for pushers and place-hunters whom he did not trust in scientific matters; he knew how scientific achievement can be a matter of character quite apart from natural gifts. Even if Müller did sometimes incline toward a pessimistic view of human nature, this pessimism became tempered, as the years went on, by a deliberately cultivated sense of humor. In his literary criticism Müller delivered many a harsh judgment; sometimes he said to me long afterwards, " Perhaps I might have said the same thing but with less harshness ".

Müller's death marks the outward close of a life rich in learning and research; his name will never lose its luster in the history of experimental psychology. Nowadays, with the widening of its scope and the setting-up of fresh goals, psychology has opened up many new channels, but it can never afford to set aside the ideal of strict accuracy for which Müller strove more valiantly than anyone else. Müller's friends and followers will always remember him with feelings of esteem and inextinguishable gratitude.

RETROACTIVE INHIBITION: A REVIEW OF THE LITERATURE[1]

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I. The Concept of Retroactive Inhibition; Definition

The phenomenon in retention, known as retroactive inhibition, has long been recognized by psychologists and is experimentally established. However, at no place in the literature is there a complete summary of all the experimental work in this field together with a review of the articles which discuss this important phenomenon.[2] The purpose of the present paper is to review all of the studies, through December, 1934, which either subject retroactive inhibition to experiment or discuss it from a theoretical standpoint. The historical development of the concept will be considered, the various experimental variables will be discussed, the resultant conclusions will be stated, and the theoretical implications will be reviewed.

There is agreement for the most part as to the meaning of the term "retroactive inhibition". It is well recognized that the degree of revival of a previously acquired activity depends on the kind and amount of activity which intervenes between the original learning of the activity and its reinstatement. "In those instances where the intervening activity interferes with the reinstatement of the previously acquired activity, the phenomenon has frequently been termed *retroactive inhibition* . . . " (13). For example, if the learning of a problem is followed by the learning of a second problem, the score on retention of the first problem will, as a rule, be poorer

[1] The writer wishes to express his appreciation to Professor Marion E. Bunch of Washington University for his initial stimulation of interest in the general field of psychology, for his suggestion of the present study, and for his encouragement and helpful advice. The writer is also indebted to Professor Edward S. Robinson of Yale University for his interest in the project.

[2] Skaggs (116) has written on the major forms of inhibition in man, but his treatment of retroactive inhibition reviews only a few experiments and is not intended to be a complete résumé.

than if the original learning had been followed by a period of rest or "usual" type of activity.[3]

At least two writers, however, have raised objections to the use of the term "retroactive inhibition". Vélinsky (130) feels that the adoption of the word "inhibition", the second half of the term, is not a wise one. In discussing the work of Müller and Pilzecker (89), he says: "Il nous semble que le nom de 'Hemmung' est mal choisi et qu'il s'agit plutôt de surpasser, surmonter, excéder une association par une autre, dont la quantité de la valeur dynamique de la liaison est plus grande. . . . Si je tâche d'apprendre l'association '*a-b*' immédiatement après avoir appris l' '*a-c*', ce n'est pas celle-ci qui est détruite par celle-là."

Peterson (97) objects to the term "retroactive inhibition"—as to the first half of the term, it seems—and would abolish it. In commenting on some experimental work by McGeoch (71), Peterson says that he certainly would not interpret the results "by the assumption of retroactive inhibition, which somehow acts back on and undoes certain learning fixed in the past". A term should be discontinued "that is so objectionable in its implications of a particular interpretation which may be weak". McGeoch (68) replies to Peterson's criticism thus: "As used in the experimental literature, 'retroactive inhibition' signifies only the fact of poorer retention when some activity, usually a learning activity, has been interpolated between an original learning and the measurement of its retention, than when a period of comparative rest has intervened. The interpolated activity 'retroacts' the original only in a metaphorical sense. It is as *if* the interpolated material acted backward on the original."[4]

Skaggs (114) has suggested that the term "retroactive inhibition" should be confined to situations with the normal person in which mental activity results in *permanent* effacement of previous learning, excluding from consideration all emotional and affective influences. An experience should be "blotted out" if the phe-

[3] As a hypothetical case, "if a student studies French for an hour and immediately thereafter turns to an hour's study of German or Italian, his ability to recall the French will be less than it would have been had he permitted a rest interval of no learning activity to intervene" (63).

[4] The term is further defended by McGeoch (1) because it has been used so long in the literature; (2) because its definition as a phenomenon does not imply an explanation; and (3) because science employs other terms which are far more metaphorical, *e.g.*, "refractory phase".

nomenon is to be called a case of retroactive inhibition. Recently, however, (116) he admits that this view is too severe and that there might be "a weakening of the original associative bonds which would result in a delayed or hesitating recall but not necessarily in a complete and permanent 'blotting out'".

In the present review all experiments will be discussed in which any change in interpolated activity is associated with a change in the amount of retention, since retroactive inhibition, in the usually accepted sense, is involved. In other words, every article will be considered which demonstrates that retention has been detrimentally affected by activity interpolated between learning and recall, regardless of whether this interpolated activity consists of additional learning or is "emotional" in nature.[5] Retroactive inhibition, then, may be defined as *the detrimental influence of subsequent activity upon the retention of previously established activities*. The phenomenon is also referred to as retroactive interference and as retroaction.

II. The Importance of Retroactive Inhibition as a Major Condition of Forgetting

The importance of retroactive inhibition as an explanation of forgetting was recognized by Foucault (26) as early as 1913.[6] He said: "Nous voyons donc que ce qui produit l'oubli, ce n'est pas le temps, mais la façon dont il est rempli. L'oubli, c'est le refoulement des souvenirs dans un subconscient de plus en plus éloigné de la conscience, et ce refoulement est produit par les actes psychiques consécutifs à la fixation.—Et nous voyons que ces actes ont une

[5] Excluded from consideration are the following: clinical cases of retrograde amnesia or of retroactive amnesia; "delayed-reaction" or "delayed-response" experiments (*e.g.*, Hunter, W. S., The Delayed Reaction in Animals and Children. *Behav. Monog.*, 1913, **2**, No. 6. Pp. 86); the conditioned-response phenomenon of disinhibition.

[6] In 1910, Renda (101) and Paulhan (94) had recognized the general principle. Renda said (according to Bean, 4): "Forgetting is not merely an accidental characteristic of mental function, but is the result of an active process of dissociation." Paulhan declared: "L'inhibition, la tendence réductrice peut s'exercer soit pour empêcher un fait psychique de se produire, soit pour arrêter, pour modifier, pour faire disparaître un fait déjà produit. . . . Ces qualités du souvenir décroissent progressivement, ce n'est pas que le temps les dégrade par lui-même, mais 'la continuité progressive de l'evanouissement du souvenir n'est que la continuité du courant rénovateur de la conscience.'"

puissance inhibitrice qui varie avec leur nature." In 1918 (27) he maintained that forgetting is not "l'ouevre du temps" but "est un cas particulier de la concurrence des états psychiques, qu'il se ramène à l'inhibition régressive, c'est-à-dire que les souvenirs que nous venons de fixer, à un degré quelconque, sont refoulés par les états psychiques qui leur succèdent dans la conscience". Piéron (98) contested this idea, but Foucault in a still later article (28) stated that "les inhibitions régressive sont ce qui constitue l'oubli n'est rien de plus que l'abaissement plus ou moins rapide des images par la concurrence des états psychiques consécutifs".

Jenkins and Dallenbach, McGeoch, Störring, and van Ormer have expressed much the same idea.[7] Jenkins and Dallenbach (53) suggested that "forgetting is not so much a matter of the decay of old impressions and associations as it is a matter of the interference, inhibition, or obliteration of the old by the new". McGeoch (70) holds that the law of disuse is roughly true but is too general to be important. "To say that mere disuse, time unfilled for the acquisitions in question, will account for forgetting is, even were the correlation perfect, to enunciate a proposition too general to be meaningful. Time, in and of itself, does nothing." The significance of disuse is simply that it allows "other and more specific factors" to operate, namely, "retroactive inhibition and altered stimulating conditions".[8] Störring (123) says: "Nicht die Zeit an und für sich, sondern die Eindrücke in der Zeit tragen normalerweise zum Vergessen der alten Eindrücke bei." Van Ormer (128) maintains that a revision of the law of disuse is necessitated by the results of studies on sleep and retention, combined with those on retroactive inhibition. He says that ". . . it is quite possible that forgetting is a function of the nature of the interpolated experience, the altered environmental contexts, and the organic state of the individual during and subsequent to learning, rather than intrinsically a function of the period of disuse".[9]

[7] Also, *cf.* Crosland (18).

[8] McGeoch has since pointed out that the fact that poetry (79) and prose (80) are susceptible to retroaction lends support to the theory that retroactive inhibition is a major theory of forgetting.

[9] And *cf.* van Ormer (129). The importance of retroactive inhibition in explaining forgetting has also been noted by Purdy (99). Hunter (49) says: ". . . The loss of retention varies with the lapse of time; but, as the lapse of time increases, the quantity of interpolated activity also increases. It is to this latter factor that we must look for the explanation of the loss."

III. Early Experimental Work

Although Ebbinghaus (**23**) did not deal specifically with the phenomenon which is now known as retroactive inhibition, he worked on the problem of loss of retention of a learned activity due to increasing the duration and quantity of the interpolated activities. He thus paved the way for all the experimental work on forgetting as affected by retroactive inhibition. So far as the writer can determine, the first to publish studies which involved anything like a retroactive "set-up" were: Münsterberg (**91**) and Bigham (**5**) in 1894; Baldwin and Shaw (**3**), Warren and Shaw (**133**), and Lewy (**58**) in 1895; and Calkins in 1896.[10] Retroactive inhibition was not yet a recognized phenomenon, however, and the problem was dealt with only incidentally.[11] Yet to Bigham (**5**) (working under Münsterberg) should go the credit for being the first to conduct a learning experiment in which both the length of the time interval between original learning and recall was varied and also the nature of the interpolated material.

His experiment was conducted in the winter of 1893–1894 on 6 subjects, using for learning material numbers, colors, forms, words, and nonsense syllables, each type of material being presented visibly part of the time and audibly part of the time. The time intervals were 2, 10, 30, and 60 seconds, and they were filled with the reading by the subject of newspapers, etc., or by the experimenter reading them to the subject. One conclusion was: "For both fillings and in each of the intervals the hinderance is least for the numbers, and increases for colors, forms, words, and syllables; but while for all the other contents the acoustical filling hinders more than the optical, the opposite is true for the words."

Müller and Pilzecker (**89**), however, are usually given the credit of being the first workers in the field of retroactive inhibition. In 1900 they published a study in which they had varied the character of the activities interpolated between original learning and the test for retention in order to determine whether or not the character of these activities influenced the efficiency of recall.[12] In their experiment some interpolated conditions were followed by poorer recall than others, and the phenomenon of such activities interfering with

[10] In 1891 von Kries (**131**) had noted that the memory of a seen extent fades very quickly when the time following its perception is filled with some other activity; and in 1892 Münsterberg (**90**) reported interference effects in the simple habit of changing his watch from one pocket to another for a time, and later shifting it back to the original pocket.

[11] Studies by Breese (**8**) in 1899 and by Bair (**2**) in 1902 also bear on the problem.

[12] Their work was noted by McDougall (**62**) in 1901.

the retention of previously learned material was termed by them "rückwirkende Hemmung" (translated as "retroactive inhibition"). They worked with paired nonsense syllables exposed on a memory drum, and allowed a definite time interval to elapse before the retention test for the series was made, this interval being one either of "rest" or of some specific form of mental activity. This interpolated activity consisted of the study of a second series of syllables in all but 2 of the experiments. In these 2 cases the subjects studied landscape pictures during the interpolated period and were asked to describe the pictures after they were removed from view. The results showed that the recall of the previously learned syllables was not as complete nor as rapid after a period of assigned mental activity as it was after a period of rest. Also, a comparison of the results after pictures had been studied with the results after syllables had been studied showed that the forgetting process was as great in one case as in the other. This fact led Müller and Pilzecker to conclude that the decrease in retention, the retroactive inhibition, was produced by indulging in any definite activity, as compared with rest, during the interval.

Müller and Pilzecker employed the method of recall for the most part. In part of their experiments their results were computed by the method of right associates, and the "association" times were determined by means of a Hipp chronoscope. In other experiments their results were by use of the saving method. In one part of their experiment they used a single subject, and compared the amount of retroactive inhibition where the interpolated activity followed 17.2 seconds after memorizing with that where the activity followed 6 minutes after memorizing. From their results they concluded that the earlier the work is engaged in after memorizing, the greater is the resulting inhibition.

Meyer (84) in 1910 was the next investigator to study retroactive inhibition.[18] The learning of simultaneous complexes (complexes of simple colored figures) was followed by adding, using "Kraepelin's Rechenhefte", and as a control the time interval was filled "mit bloss ablenkender Lektüre". Somewhat different conditions were employed with 3 observers, and with 2 of them there was definite evidence of retroactive inhibition.

In part of Sleight's (118) study in 1911, 4 groups of subjects were tested in ability to learn dates, nonsense syllables, poetry, prose, prose substance, and letters. Over a three-weeks interval, Group I received no additional training

[18] Experiments had been reported in 1905 by Ebert and Meumann (24), in 1907 by Radosavljevich (100), in 1908 by Book (6), and in 1909 by Gamble (32) which are related to the problem of retroactive inhibition. (*Cf.* Bean, 4, for description of 24 and 6.)

on these tasks, while Group II was trained in learning poetry, Group III in memorizing tables of various contents, and Group IV in learning prose substance; all groups were then tested on the original tasks. Training in learning poetry had a beneficial influence on the test of poetry and of nonsense syllables, but a detrimental effect on the test of letters and of prose substance. Similarly, practice in learning prose substance had a beneficial effect on the prose-substance test, but a "disastrous effect" on the nonsense-syllables test.[14]

In part of Foucault's (26) experiment in 1913, he employed lists of artificial words for both original and interpolated material and had 3 conditions: "short interval" of learning; "long interval" of learning; and "empty interval", comparable in time to the "short interval", during which the subject and experimenter chatted "amicalement de n'importe quoi". With all 4 subjects the percentage of forgetting was least for the "empty", more for the "short", and most for the "long" interval.[15]

The next really important study, after the work of Müller and Pilzecker, was published by Heine (39) in 1914.[16] Her experiments, conducted in Müller's laboratory, were designed to determine whether or not retroactive inhibition played the same part for recognition memory that Müller and Pilzecker had found for it in connection with recall memory. In none of her 19 experiments using the method of recognition was evidence of inhibition found. Heine carried on 14 additional experiments, using either the method of right associates or the method of saving. The memorized material was principally nonsense syllables presented on a memory drum. The interpolated work consisted of the study of pictures, lists of four-place numbers, or consonants. In these experiments, with measurements in terms of recall memory, the results of Müller and Pilzecker were substantiated. All forms of interpolation showed inhibition as compared with rest.

Heine also used 7 subjects in attempting to find the relationship between degree of learning and susceptibility to retroactive inhibition. Her results indicated a greater degree of inhibition for the more weakly established associations. She used nonsense syllables and varied the number of repetitions which they were given in the learning test. Since there was greater inhibition in all cases for the lists given the fewer repetitions, she concluded that the amount of inhibition is

[14] For additional comparisons, see Sleight's Table V.

[15] Foucault also noted that sleep may protect memories from the destructive action which waking activity exercises.

[16] In 1912 Müller (88) had given a brief report on Heine's (39) investigation. Also relevant to retroaction were the studies by Bean (4) in 1912, and by Finkenbinder (25) and by Tait (125) in 1913. Publications in 1914 by Strong (124) and by Frings (31) showed that they recognized the importance of the principle of retroactive inhibition.

inversely related to the degree to which the disintegrated material is learned. However, it should be noted that Heine's interpolated work was comparatively dissimilar to her original learning problem, and, in view of recent experimental work (discussed below), this material probably did not produce as much retroactive inhibition as would a more similar material. Also, she used only 2 degrees of learning; hence, her results concerning the exact relationship between varying degrees of learning and varying degrees of retroactive inhibition are indicative rather than conclusive.

Heine also studied the problem of retention and interval of sleep. She tested 4 subjects with the method of saving, and 2 subjects with the method of paired associates, using nonsense syllables. These were learned immediately before going to bed, and were learned with waking intervals in between learning and sleep. Under both conditions retention tests were taken 24 hours later, and the results in all cases definitely favored sleep. This was interpreted by Heine as due to the elimination of retroactive inhibition which, in the case of day activities, ordinarily follows learning.

DeCamp (21), in 1915, and Webb (134) and Tolman (127), in 1917, were the first in this country to study retroactive inhibition systematically.[17] DeCamp conducted a series of 12 experiments with nonsense syllables, and 1 experiment with arrangement of chessmen on a chess-board, as the learning material; the interpolated activity consisted of ergographic work, mental multiplication, and chess-playing. DeCamp says: "Considering our experiments in their totality, the majority of them *slightly* favor a trace of retroactive inhibition." Yet his final conclusion is: "That retroactive inhibition plays a significant part in influencing the recall of nonsense-syllables, appears exceedingly doubtful."

Webb used maze habits for both original and interpolated learning with rats and human subjects, and obtained reliable evidence of retroactive inhibition ("negative retroaction" in his terms). Tolman, using words, numbers, and nonsense syllables for original learning materials, studied the relationship between retroactive inhibition and 4 different sets of conditions: pleasant *vs.* indifferent lists; normal *vs.* distracted attention; with caffeine *vs.* without caffeine; efficient *vs.* inefficient working periods. The variables of Webb and of Tolman will be discussed below in the appropriate sections.

[17] It should be noted, however, that certain aspects of Hunter's (45, 46) and of Hunter and Yarbrough's (50) work on rats involved a retroactive "set-up". Also, Roback (102) noted retroactive inhibition in his study of the interference of will-impulses.

IV. The Determining Conditions of Retroactive Inhibition

(1) *The Degree of Similarity Between the Original Activity and the Interpolated Activity.* The amount of similarity between the original and the interpolated activity has been the subject of more experiments than has any other variable.[18] Two experimenters, whose results were perhaps a function of the degree of similarity between original and interpolated activities, have found little or no evidence for retroactive inhibition. This does not imply, however, that either experimenter would deny the existence of the phenomenon; in fact, one of them, DeCamp (**21**) has noted the importance of the similarity factor and has formulated one of the major theories of retroaction. The other, Brockbank (**11**), as one part of a maze experiment with albino rats, interpolated a rope-ladder problem during the retention period and found that this did not interfere with the retention of the maze habit. However, he states that some problem different in nature from that of the rope ladder, and more difficult to master, might possibly be detrimental to the retention of the maze habit.

The first major study of the similarity factor was reported by Robinson (**103**) in 1920. In 2 experiments the subjects memorized series of 8 four-place numbers and took retention tests after an interval of from 3 to 5 minutes. In the first experiment the interpolated activities were the learning of more four-place numbers, of a series of 20 consonants, of poetry (Scott's "Rokeby"), the multiplication of four-place numbers by four-place numbers, and the reading of a story. The first condition, the learning of another series of four-place numbers, gave an appreciably smaller recall score than the other 4 conditions, while these other 4 conditions resulted in substantially the same scores.

[18] Müller and Pilzecker (**89**) apparently did not regard the similarity factor as important. This variable should be noted, however, in interpreting Sleight's (**118**) and Heine's (**39**) results.

One of the earliest distinctions as to the effect of the type of interpolated material was made by Tait (**125**) in 1913: "Ideas are more affected by other similar mental material than by sensory disturbances, unless these latter arouse strong psycho-physical attitudes, *e.g.*, the pistol shot." Also Strong (**124**) wrote in 1914: "Book told me a few days ago of some work he had just finished. He found that nonsense syllables were best retained if a short period of rest followed the memorizing. If a problem in arithmetic followed the memorizing, the syllables could not be remembered so well as if the memorizer had rested instead, but they could be remembered better than if a second series of syllables were studied during that period."

In the second experiment the interpolated activities consisted of the memorization of more four-place numbers, the memorization of 32 digits, the multiplication of two-place numbers by two-place numbers, the observation of pictures of nudes, and the reading of a newspaper. This experiment, like the first, showed decided evidence of retroactive inhibition where original memorizing and interpolation were very similar, and slight evidence of retroaction where original learning and interpolation were comparatively dissimilar. Robinson points out that the degree of retroactive inhibition is a function of similarity of process as well as similarity of content; that is, similar content in the original problem and in the interpolated material did not in itself guarantee any more inhibition than where these contents were comparatively dissimilar. In Robinson's third experiment the arrangement of 6 chessmen on a chess-board was studied for 1 minute. The interpolated activities were of 3 types: studying another arrangement of chessmen, multiplication, and reading. After each one of these types of activity the subject tried to replace the 6 chessmen in their original position. The results of this study showed the greater inhibitory effects of very similar interpolation, but further showed that there may be marked inhibition even where the interpolated activity and the activity in original learning are comparatively dissimilar.

In 1924 Whitely (**136**) published a study on the dependence of learning and recall upon prior mental and physical conditions. The learning materials were lists of three-letter and four-letter monosyllabic words. The physical activities consisted of rather vigorous calisthenics for about 4 or 5 minutes, while the mental activities interpolated involved simple multiplication tasks. In one part of the experiment these activities were introduced just before recall, which was 24 hours after original learning. Whitely concluded that these mental and physical activities immediately preceding recall did not exert any detrimental effect. In view of other experimental work, however, it is possible that this was due in part to the lack of similarity between the original and the interpolated activities.

Skaggs (**113**), in 1925, published extensive data on 3 different tests, a reconstruction test in one case (arrangement of chessmen on a chess-board), a series of 12 sense words in another, and nonsense syllables in a third. He found retroactive inhibition in all 3 tests and, as a practical application of his results, advises that "it is better to rest after the learning than to turn immediately to some other vigorous and taxing work".

One experiment on the memorization of a chess formation is an example of his work on the factor of similarity. The effect of the following interpolated activities was compared: (1) memorization of a new chess arrangement, with the same board and men as in the original formation; (2) memorization of a new arrangement, with a paper board and 5 articles as chessmen; (3) problems in multiplication or addition; (4) memorization of post-card pictures of scenery. It was found that the retroactive effect increased with the degree of similarity. In another experiment, Skaggs used as the interpolated activity 3 arrangements of chessmen which apparently exhibited varying degrees of similarity to the original formation. Here, however, it was found that the retroactive effect decreased with the degree of similarity.

In summary of these and his other experiments, Skaggs states that the effect of the interpolated work upon the efficiency of the recall of the original material is more detrimental, "within limits", as the similarity between the original and the interpolated material increases. His formulation of the general relationship is as follows:

"A. When work and original learning are identical in content and method there is only reinforcement or repetition. There is no inhibition.

"B. As the material is made (by degrees) more and more dissimilar the reinforcing factors gradually diminish in effectiveness and the interfering factors become more and more pronounced.

"C. As the material of learning and work is made more dissimilar a point is reached where there is a maximum of interference or detrimental influence wrought upon the original learning.

"D. Beyond this point the curve of interference or detrimental influence goes downward, and then we can say that the more dissimilar the materials the LESS the detrimental influence.

"E. However, the curve of detrimental influence never reaches zero because after the work and learning are as different as can possibly be made there is still a damaging influence exerted by the work."

A study reported by Lund (**60**) in 1926 tended to show greater retroactive effects with greater similarity, but he was employing only two degrees of similarity. He had 3 series of nonsense words of 5 letters each. Series B duplicated Series A except that *1* letter was changed in every word, and Series C was the same as Series A except that *2* letters were changed. Lund says: "The observation that recognition and confidence for Series A was greater if it preceded Series B to which it is similar, is a fact which seems most readily explained as due to retroactive effects. Apparently, interposing Series B had the effect of interfering with the connections and the neural set formed in the first presentation of Series A."

In the studies by Robinson and Skaggs, similarity had been ranked but not quantified (**67**). Since it is possible to have similarity between the original material and the interpolated material in such a wide variety of ways, Robinson (**106**) selected one important dimen-

sion of similarity which he attempted to quantify in a series of experiments in 1927. He wanted to determine the correctness of a general law as to similarity: "*As similarity between interpolation and original memorization is reduced from near identity, retention falls away to a minimum and then rises again, but with decreasing similarity it never reaches the level obtaining with maximum similarity.*" In order to vary the degree of similarity in exactly increasing proportions, he carried out 3 experiments with lists of consonants for the original material and with varying numbers of these same consonants in the interpolated material. In the first 2 experiments he used lists of 4 consonants for the original learning material. The interpolated problem also consisted of lists of 4 consonants, but the degree of similarity to the original lists varied thus: 0 consonants the same as in the original list, 1 consonant common to both the original and interpolated lists, 2 consonants in common, 3 in common, and 4 in common. These first 2 experiments differed from each other only in the fact that in the first the material was presented to the eye, while in the second it was presented to the ear. In the third experiment he used 6 consonants in the original problem and employed consonants in the interpolated problems, with from 0 to 6 consonants common to the original list and the interpolated list. His results in all 3 experiments failed to demonstrate the assumed generality of the relationship expressed by the above law. There was increased retroaction with a decrease in the number of common elements. Robinson states that " the inversion of the first order " was more often absent than present. This was true with both the relatively hard and easy tasks of memorization. According to Robinson, his most striking and important result was that there were no inversions in the curves at complete dissimilarity, although, according to the hypothesis, this condition should have facilitated recall. However, it should be noted that the condition here which was ranked by Robinson as complete dissimilarity is the condition which has elsewhere been used as the greatest similarity, namely, the same sort of material.

A second experiment by Whitely (137) was reported by him in 1927. He introduced different types of material following the learning of the original material. In some cases this interpolated material was "congruous" and in other cases "non-congruous" to the original material. Whitely's results showed greater inhibition with the more congruous, or more similar, material.

Whitely and McGeoch (138) studied the effect of a narrative account of an event upon an interrogatory account of the event, and *vice versa*. They concluded that the interpolation of an interrogatory form of report immediately following a narrative report has a facilitating effect upon subsequent narrative

recall at 30-, 60-, 90-, and 120-day intervals. However, a narrative report interpolated prior to interrogatory recall did not facilitate recall or report.

Cheng (16) wished to find whether or not the relation between retroaction and similarity differed for two methods of measuring retention: anticipatory recall and relearning. With 53 subjects, he used for the original and interpolated materials lists of nonsense syllables which exhibited 3 degrees of similarity with respect to spelling. The conclusion was that the relation between degree of retroactive inhibition and degree of similarity varies with the method of measurement. When measured by the recall method, retroaction at first increases and then decreases as the degree of similarity increases from zero to approximate identity. The measures by the saving method were not consistent enough for a definite conclusion.

Harden (37) has carried out an experiment on retroaction, her purpose being to supplement Robinson's (106) study on the similarity factor. With 10 subjects, she studied how much the interference in the recall of 4 consonants varied with the consonant-digit composition of a list of 4 members presented immediately following the presentation of these consonants. Whereas Robinson had used consonants entirely in both original and interpolated learning, Harden introduced a mixture of both consonants and numbers. The important difference in their two experiments, as to similarity, may be indicated in schematic form:

Elements in common	Robinson		Harden	
	Original	Interpolated	Original	Interpolated
None	a-b-c-d	e-f-g-h	a-b-c-d	1-2-3-4
One	a-b-c-d	a-f-g-h	a-b-c-d	e-2-3-4
Two	a-b-c-d	a-b-g-h	a-b-c-d	e-f-3-4
Three	a-b-c-d	a-b-c-h	a-b-c-d	e-f-g-4
Four	a-b-c-d	a-b-c-d	a-b-c-d	e-f-g-h

According to Harden's results, recall was more efficient when the original and interpolated materials were most dissimilar than when these materials were similar or mixed. This tended to substantiate Robinson's (106) prediction of a rise in retention values after a certain point in decreasing similarity had been passed.

In 1931 McGeoch (69) reported 2 experiments, using 4 different interpolations: learning, tapping, reading plus shock, and color naming. The interpolated learning was the most similar to the original learning, and resulted in the greatest amount of retroactive inhibition.[19]

[19] Alm (1) in 1931 also called attention to the importance of the similarity factor.

In the same year McGeoch and McDonald (78) reported 2 experiments which bear directly on the findings of Robinson and Skaggs. They employed the anticipation method, and attempted to quantify similarity in terms of the ratings of large numbers of judges. In the first experiment, with 32 subjects, lists of 10 adjectives constituted the original learning material, while the interpolated learning consisted of adjectives, nonsense syllables, and three-place numbers, each rated as to similarity of meaning to the original material. In the second experiment, with 24 subjects, the original learning was also of adjectives, but the interpolated learning was of synonyms of these adjectives, the synonyms being divided into 3 classes by judges on the basis of their degree of relation to the original list. The rest condition in each experiment consisted of reading jokes. The results showed that "the learning of interpolated lists of synonyms, antonyms, unrelated adjectives, nonsense syllables, and 3-place numbers produces retroactive inhibition in amounts which decrease steadily from synonyms to numbers, until with the latter material inhibition becomes very small". Retroaction also varied directly with the degree of rated similarity of the interpolated material. McGeoch and McDonald discuss the Skaggs-Robinson prediction that the curve of retroactive inhibition rises from zero inhibition when the original and interpolated materials are identical to a high point some place between identity and very great dissimilarity, and then falls to a small amount of inhibition at a later point. They state that their results do not follow this curve at all.[20]

Bunch and McTeer (13), in their study of the influence of punish-

[20] In 1931 James (52) also criticized the interpretations of Robinson and Skaggs on the matter of similarity. James maintains that there are two kinds of inhibition or interference: (a) "that due to the variation of the response where a given response is to be maintained in spite of variation of the situation"; and (b) "that due to generalization or maintenance of the response where it is required to vary the response". He further holds that it is entirely unnecessary for Robinson and Skaggs to assume that, as the factor of similarity decreases from identity to complete dissimilarity, there is at first a drop in the recall score and then a rise, although never to the original height. Rather one should consider "that in the repetition of the same series with a view to learning it, any interference that arises will be due not to similarity but to lack of similarity in the experimental situations, such as might be caused by variation of the experimental conditions. Here the interference is of the first kind. It is only in regard to the second kind of interference that increase in situational similarity will give rise to an increase of interference. It is clear that the effect of situational similarity differs according as the response is to be modified or to be maintained unchanged."

ment during learning upon retroactive inhibition, found that retroaction, except as to trials, was decreased approximately one-half by punishment (electric shock) either during original maze learning or during interpolated maze learning. Although the results are not interpreted as due to the factor of decreased similarity alone, this is offered as one possible explanation. It is pointed out that punishment for errors in either the original or the interpolated learning decreases the amount of similarity between the 2 learning problems, as compared with normal (non-punishment) conditions, and that it is possible that this decrease of similarity also decreases the detrimental effect of the interpolated problem.

In studying the similarity factor, Dreis (**22**) used for learning materials a substitution or code test—the Binet-Simon substitution of geometric symbols, but used it in reverse order to avoid any effects due to previous familiarity with the material. The method of relearning was employed with 179 subjects, divided into 5 groups. The first condition was 3 minutes for work, 3 minutes for rest, and 3 minutes for work again. In each of the other 4 conditions, instead of the rest period, there was an interpolated test with 0, 2, 3, and 4 elements respectively in common with the original learning. On the basis of the percentage of saving, the general tendency was for saving to increase as the number of elements in common with the original learning was increased from 0 to 4: 24.9%, 26.5%, 34.9%, and 33.0%. Dreis states that in the fourth condition with an inversion of the relationship, a saving of 34.9%, "the magnitude of the irregularity suggests that it is merely a statistical accident". Therefore, she concludes that there was "no inversion with increasing similarity of interpolated material and original learning", and that the general law as to similarity as set forth by Robinson (**106**)[21] was not verified. Dreis's results are in agreement with those of Robinson (**106**) "in the ultimate absence of inversion with increasing similarity", although his results were measured by the method of recall and hers were measured by the method of saving.

In their study as to the affective nature of the learning material, the degree of similarity between the two learning problems is considered as one possible explanatory factor of their results by Bunch and Wientge (**14**). ". . . On the basis of slightly greater similarity, indifferent material might be expected

[21] The importance of the similarity factor has also been discussed by Skaggs (**117**), in connection with the temporal effects of interpolated mental activity; in any study of this factor, he suggests that the interpolated task should be as different as possible from the original task.

to have a greater detrimental effect upon the retention of indifferent material than upon pleasant or unpleasant material. The results, however, are not consistent in indicating greater retroaction when the original material is indifferent than when pleasant or unpleasant; and the similarity factor could hardly account for the differences between pleasant and unpleasant material in the susceptibility to retroaction."

Johnson (**54**) has studied the factor of similarity of *meaning* by using a list of 21 abstract nouns for original learning material and 3 other lists of 21 abstract nouns for interpolated material, the interpolated lists having been ranked 1, 2, and 3 by 15 graduate students as to their relative degree of similarity of meaning to the corresponding words in the original list. Using the anticipation method, each of 29 subjects was given all 4 conditions of the experiment. An interpolated list was learned in each of the first 3 conditions, and the remainder of a twenty-minute interval was spent in newspaper reading or conversation. The fourth condition was newspaper reading or conversation for 20 minutes. Retention was less efficient in the first 3 conditions than in the fourth, and retroactive inhibition decreased as the similarity of meaning between original and interpolated learning decreased.

The effect of similarity of *form* has been investigated by Peel (**96**). For original learning, paired associates were used in one experiment and serial learning in the other. The work conditions in both experiments were paired-associates learning and serial learning. Retroaction was definitely greater when the original and interpolated learning had the same general form.

This has also been demonstrated in one part of von Restorff's (**132**) study. Forty-eight students, divided into 3 groups of 16, 15, and 17, were presented 3 times with a series of 2 syllables, 2 designs ("Figuren"), and 5 numbers. Group I was then shown 6 other syllables and 3 numbers twice and tested on these; Group II was shown 6 other designs and 3 numbers twice and tested on these; Group III, the control, had no additional learning, but worked on "Denkaufgaben". Ten minutes after the original series, all 3 groups were tested on the original material. The designs were remembered better by Group I than by Group II, and the syllables better by Group II than by Group I, while Group III was superior to either.

In order to study retroactive inhibition in the case of meaningful and interrelated material, McGeoch and McKinney (**79**) used poetry.

With 188 subjects (3 groups of about 60 each), the original material was 12 lines of poetry, which was studied for 5 minutes and then recalled for

5 minutes before new material was introduced. The interpolated work conditions were either the study and recall for 5 minutes each of a second 12 lines of poetry from the same poem and the taking of a Seashore discrimination test for 5 minutes; or the study and recall for 5 minutes each of 20 nonsense syllables and the Seashore test for 5 minutes. The "rest" condition consisted of taking the Seashore test for 15 minutes. A retention test was taken on the original material immediately after the interpolated activity, and again 7 days later, 5 minutes being allowed for recall in each case. The experiment was repeated with another group of subjects, using only the first work condition and the rest condition, and omitting the retention test after 15 minutes.

The interpolation of poetry resulted in a small degree of susceptibility to retroactive inhibition after 15 minutes, but this susceptibility increased considerably after the delay of 7 days; the interpolation of nonsense syllables produced the same general effect. With poetry interpolated, susceptibility to retroaction after 7 days was greater when there had been no intermediate recall after 15 minutes.

McGeoch and McKinney (**80**) then conducted another investigation which paralleled the experimental procedure of the previous one (**79**) exactly, except that prose was employed: wherever poetry was used in the other experiment, prose was substituted in this one. Also, when the experiment was repeated without the retention test after 15 minutes, the second work condition was also included. The prose selection was of the same kind for both original and interpolated material, and in each case contained 20 specific facts or ideas. The interpolation of prose resulted in a small degree of susceptibility to retroactive inhibition after 15 minutes, but this susceptibility increased slightly but somewhat uniformly after the delay of 7 days; the interpolation of nonsense syllables produced nearly as large an amount of retroaction as the interpolation of prose. Susceptibility to retroaction after 7 days was not greatly affected by the recall after 15 minutes.

The most recent experiments on similarity are by Gengerelli (**33**) and by Gibson and Gibson (**34**). Gengerelli used as the criterion of similarity the degree of correlation between the original and the interpolated activity.

All the tasks were of the pencil-and-paper kind, and the interpolated task varied from objective identity with the original to $r=0$. The original activity was a code transcription test, identical with that used by Dreis (**22**). The interpolated task for each of 5 groups was another code transcription test, and for 3 other experimental groups, problems in addition, a letter-checking problem, and dotting circles, respectively. These 8 groups had the original activity for 5 minutes, rest for 1 minute, interpolated activity for 3 minutes, rest for 1 minute, and resumption of original activity for 5 minutes. The ninth group (control) had the original activity for 5 minutes, rest for 5 minutes, and resumption of original activity for 5 minutes.

It was found that, as the degree of similarity decreased from identity, the amount of retroactive inhibition increased sharply until it reached a limit at $r=.73$. Here there was an inflection in the curve and it rose sharply until a limit was reached at $r=.64$, which was the point of minimum retroaction. As the similarity diminished further, the amount of retroaction increased steadily until the point of zero similarity was reached.

Gibson and Gibson (**34**) have studied the features of similarity in *operation* and similarity in *material* between the original and interpolated activities.

Five groups of about 26 subjects each studied a list of 10 pairs of consonants for 2 minutes. After 30 seconds of instructions, they spent 3 minutes on the interpolated task, and then, after brief instructions, recalled the original material for 1½ minutes. The interpolated activity differed with each group. Group I had an interpolated task like the original in both operation and material, *viz.*, the learning of another list of paired consonants. Group II had an interpolated task similar in operation but different in material, *viz.*, the learning of a list of 10 pairs of digits. Group III had material similar in kind but different in operation, *viz.*, cancelling the paired consonants "KS" whenever they appeared in a sheet of pied type. Group IV had material different in both operation and material, *viz.*, cancelling a digit combination in the same manner. Group V, the control group, looked at moving-picture "stills". In retention, the groups ranked in the following order: V, IV, III, II, I.

It was concluded that an interpolated task similar to the original learning either in *operation* or in *material* results in poorer retention than an interpolated task similar in neither, and that these two features are about equally important in this experiment. The fact that Group V had better retention scores than Group IV indicated that the two features of operation and similarity are not the *only* ones on which a comparison may be based. Also, the fact that the sum of the decrements of Groups II and III was not as great as the loss in retention in Group I, suggested that the two features studied were interdependent.

(2) *The Temporal Position of the Interpolated Activity.* As was pointed out in the discussion of their experimental work, Müller and Pilzecker (**89**), and Heine (**39**), concluded that the earlier the interpolated work is engaged in after memorizing, the greater is the amount of retroactive inhibition. The matter was subjected to experimental study by Robinson (**103**). With 5 subjects he used lists of 10 three-place numbers for the original learning material, and employed an interval of 20 minutes between the learning test and

the retention test. The interpolated activities consisted of reading a newspaper and learning a second list of numbers. The second list was interpolated in 4 different temporal positions, namely, the first 5 minutes, the second 5 minutes, the third 5 minutes, and the last 5 minutes. Also, under one condition, the entire 20 minutes were spent in reading and there was no interpolated memory material. Robinson found no consistent relation at all between the detrimental effect of the interpolated activity and its temporal position. He says: "Under the conditions of this experiment, at least, the degree of retroactive inhibition is independent of the temporal position of retroactive interpolation."

Spencer (**119**), however, found "less retroactive inhibition on the average after a 20-min. interval than when the interval is 9 sec." With 27 subjects he employed packs of nonsense-syllable cards. In one case there was a nine-second interval between original learning and interpolated learning, and another nine-second interval between interpolated learning and relearning of the original material. In another case the interval between original learning and interpolated learning was 20 minutes, and the interval between interpolated learning and relearning was also 20 minutes. Spencer says that the results "make it evident that the interval of 20 min. *may* reduce the retroactive effect upon the retention of the original material". Robinson (**105**) says that Spencer's results are "quite as likely . . . due to the fact that the retroaction of his experiment was measured at two different temporal positions after original learning as to the fact that two temporal positions were employed for the interpolated learning". In Robinson's (**103**) experiment "there was a total interpolated period of *constant* length within which the interpolated learning was placed in varying temporal positions" (**105**).

The first experiment of Whitely's (**136**) (mentioned above) showed no detrimental effect of physical activities of vigorous calisthenics and mental activities of simple multiplications introduced 24 hours after original learning of words and just prior to recall.

The temporal position of the interpolated work was considered significant by Skaggs (**113**) (experiments also mentioned above). The following is an illustration, from a reconstruction test, of the type of variations employed:

1. Learn—Work 3 min.—Rest 7 min.—Reconstruct.
2. Learn—Rest 3 min.—Work 3 min.—Rest 4 min.—Reconstruct.
3. Learn—Rest 5 min.—Work 3 min.—Rest 2 min.—Reconstruct.
4. Learn—Rest 7 min.—Work 3 min.—Reconstruct.

From different temporal variations on 3 different types of tests, reconstruction, sense words, and nonsense syllables, he concluded that, where work is introduced immediately following the original learning, it has a more detrimental effect on the original learning than work introduced after a rest interval. Thus, his work tended to confirm the conclusions of Müller and Pilzecker and of Heine.

On the other hand, the results of a later experiment by Whitely (137) (mentioned above) are not in accord with the conclusions of these investigators. In part of his experiment, he found the greatest inhibitory effect when the interpolated material immediately preceded recall, the next greatest when it preceded original learning, and the least when it followed immediately the learning.

Since the work of Bunch and McTeer (13), there can be little doubt that retroactive inhibition may occur even though the interpolated activity is not introduced until long after the completion of the original activity. Studying the influence of punishment during learning upon retroaction, these investigators used stylus mazes for the two types of activity and electric shock for punishment. The fact of importance with regard to the temporal position of the interpolated activity is that a normal (non-punishment) group mastered the second maze 3 weeks after learning the first maze and 3 weeks before the retention test of the first maze, whereas another normal group simply had an interval of 6 weeks between original learning and retention test of the first maze. Except for trials, all criteria showed marked retroactive inhibition for the group with the interpolated activity.[22]

With 132 subjects, and employing the anticipation method with lists of 10 adjectives for learning materials, McGeoch (74) has made a comparison between the amounts of retroaction after intervals of 20 minutes, 1 hour, 24, 48, and 144 hours, when the interpolation occurred (1) immediately after original learning, and (2) just prior to relearning. Retroaction tended to be greater by all measures of retention (except for small differences at the twenty-four-hour interval with part of the subjects) under condition (2) than under condition (1). There was "no consistent increase with interval in the differences between the amounts of inhibition at the two positions. . . ."

[22] Other recent experiments, by Lester (56), by Bunch and Wientge (14), and by Britt and Bunch (10), with interpolated learning just before recall and 24 hours, 48 hours, and 48 days respectively after original learning, are a further demonstration of the fact that there may be marked retroaction even though the interpolated activity does not follow the original activity immediately.

McGeoch and Nolen (**81**) have devoted a special study to this 24-hour interval. Three groups (of approximately 25 subjects each) learned a stylus maze and relearned it 24 hours later. Group I (control) had no interpolated laboratory learning. Group II learned a second maze immediately after the first maze. Group III learned the second maze just prior to relearning the first maze. The interpolation did not result in important differences in Groups II and III in the decrements produced.[23] Skaggs (**117**) has suggested that it is barely possible that the learning of the second maze just before relearning the first maze (Group III) tended to introduce confusion into the recall of the first maze, and if so, this was not a case of retroactive inhibition at all but one of *reproductive inhibition*. He believes that it would have been more desirable to have introduced the second maze an hour, 2 hours, or 10 hours after original learning. He also believes that, in any experiment on the temporal effects of interpolated activity, the interpolated task should be "as different as possible from original learning", and that McGeoch and Nolen might well have "used, instead of a maze, mental multiplication, the learning of a poem, or the studying of some material which demanded keen attention and effort".

(3) *The Time Interval.*[24] McGeoch (**73**) has recently attempted to determine the course of retroactive inhibition after intervals of 20 minutes, 24, 48, and 144 hours.

One hundred subjects learned a list of 10 adjectives by the anticipation method. Under the rest condition (60 subjects), the subject read and marked jokes for 20 minutes, or, for the longer intervals (1 hour, 24, 48, and 144 hours) read for 10 minutes following learning and for 10 minutes just before the beginning of relearning. Under the work condition (40 subjects), the subject learned an interpolated list immediately after original learning and then read jokes for the remainder of the 20 minutes, or, for the longer intervals

[23] In their study of retention in rats of an *incompletely* learned maze solution, Bunch and Magdsick (**12**) make the following observations: "An initial rise in the curve of retention of incompletely learned material will probably also be found to be intimately related to the amount of retroactive inhibition such material would suffer under conditions designed to produce the latter. It seems plausible to assume that less retroactive inhibition would follow from an interpolated problem if the latter coincided temporally with the peak of the rise in the curve of retention of the incompletely learned original material than if the interpolated problem were introduced at any other temporal position, say somewhat later than the peak, or somewhat earlier, *e.g.*, immediately after the partial learning."

[24] Also, note the study by Spencer (**119**), above; and *cf.* Whitely (**137**) as to forty-eight- and ninety-six-hour intervals.

read jokes for 10 minutes following the interpolation and for 10 minutes just before relearning the original list.[25] The 20-minute and 24- and 144-hour intervals were also studied with 12 additional subjects.

According to saving scores, the amounts of retroaction varied irregularly over a small range and did not show any regular change with increasing interval. McGeoch concludes that the percentage of inhibition was approximately a constant over the intervals used. Neither was there, according to recall scores, a consistent tendency for retroaction to vary with time. "If, however, inhibition is viewed from the standpoint of complete failure to recall and is found in terms of the percentage of cases showing any recall, it increases with interval." From the results of a second experiment (**74**) (mentioned above), McGeoch also concludes "that there is no uniform and consistent variation with time interval in percentage of retroactive inhibition".[26]

In the case of poetry (**79**) and of prose (**80**), however, McGeoch and McKinney found a greater degree of susceptibility to retroaction after an interval of 7 days than after 15 minutes. This difference in results may be due to differences in material, in method of learning, or in relative degrees of learning (**79**).[27]

(4) *The Amount of Material for the* ORIGINAL *Activity.* In 1922 Robinson and Heron (**108**) published data on the relationship between length of memorized material and its susceptibility to retroaction. The original materials were lists of nonsense syllables, of 6, 9, 12, 15, or 18 syllables. The interpolated conditions consisted either of memorizing another list of 12 syllables or of rest (newspaper reading). With 10 subjects, the anticipation method was employed throughout. Both recall and saving scores were computed. The most consistent tendency was toward "absolutely and relatively less

[25] Skaggs (**117**) has stressed the importance of a rigid control of the so-called "rest-period", holding that it should be "a care-free, drowsy state of mental relaxation" rather than devoted to such active things as reading or looking at pictures. Hence, he contends that the time interval should be very short.

[26] Although the temporal course of retroaction for incompletely learned material has not been the experimental variable in any study, the results of Bunch and Magdsick (**12**) suggest the possibility that the temporal course may vary somewhat from that for completely learned material.

[27] See (**79**) for consideration of other possible explanatory factors.

The time interval may be an important condition in other studies, *e.g.*, Myers (**92**), Crosland (**18**), Vélinsky (**130**), Chweitzer (**17**), Hill (**40**), Schroeder (**111**). Also, *cf.* below, section (9), *Diurnal Variations and Fatigue*, and section (10), *Intervals of Sleep Compared with Intervals of Waking.*

inhibition with increasing length of the disintegrated material". There was a decided exception in the case of the shortest list, the six-syllable one; in 2 of the 3 cycles according to recall and in 1 cycle of the 3 according to saving, this list showed the least inhibition. Therefore, Robinson and Heron "point out the general tendency toward decreasing susceptibility to inhibition with increasing length and the striking exception, rather too consistent to be accidental, supplied in certain cases by the material of shortest length. Evidently susceptibility to retroactive inhibition decreases with length only after a certain minimum length has been passed. It would be interesting to know whether this inverse relationship between susceptibility to retroactive inhibition and length has also an upper limit."

Robinson and Darrow (107) reported a similar experiment in 1924. Again, the anticipation method was used with 10 subjects, and recall and saving scores were computed. The materials learned, however, were lists of three-place numbers, 4, 6, 8, or 10 to a list. Interpolation consisted either of learning another list of 6 three-place numbers or of newspaper reading. With the lists of 6, 8, and 10 numbers, there was a consistent decrease in susceptibility to retroactive inhibition with increasing length. With lists of 4, however, there was some evidence of a lower limit to this tendency. The two experiments demonstrated (with the possible exception of the shortest list in each case) that susceptibility to retroaction decreased with increasing length of original material.

(5) *The Degree of Learning of the* ORIGINAL *Activity.*[28] (*a*) *To Completion.* Several experiments have been concerned with the degree to which a given material has been learned and its susceptibility to retroactive inhibition. In Heine's (39) work, where the number of repetitions of nonsense syllables was varied, there was greater inhibition for the lists given the fewer repetitions. Hence, Heine concluded that the greater the degree of mastery of the original problem, the less it is susceptible to retroactive inhibition. Two important considerations, however, are the fact that the interpolated work was comparatively dissimilar to the original material, and the fact that only 2 degrees of learning were studied.

Since Heine's conclusion was somewhat questionable, Robinson (103), in a final part of his experiment, attempted to compare the degree of learning with its susceptibility to retroaction. Using 5 subjects, he employed lists of three-place numbers and either 4, 6, 8,

[28] Also, *cf.* section (8) below, *The Amount of Practice (Previous Experience) with the Material.*

10, or 12 presentations. The assumption was made that 4 presentations would result in some learning and that more presentations would give relatively greater degrees of learning. The interpolated learning was a second list of numbers. Irregular results were obtained; no single continuous relation was found between number of repetitions and degree of retroactive inhibition.

The experiments of Robinson and Heron (**108**), and of Robinson and Darrow (**107**), however, bear directly on this point. In both experiments, the measures of retention showed that the longer lists were also the better learned; that is, there was decreasing forgetting with increasing length. Since they also showed, in general, that susceptibility to retroactive inhibition decreased with increasing length, an inverse relationship is indicated between degree of learning of the original activity and retroactive inhibition.

Although retroactive inhibition is not mentioned, part of an experimental study by Ho (**42**), using *rats*, involves the relation between degree of original learning and retroaction. Four groups had 0 trials, 3 trials, 15 trials, and complete learning respectively of a maze; each group was then given 35 trials, distributed over 20 days, in a second maze, and then relearned the first maze. On the basis of comparison with a control group, Ho concluded that the inserted practice in the second maze *facilitated* the completion of integration of the first habit, and that the degree of facilitation varied inversely with the degree of integration of the first habit prior to interpolation.

McGeoch (**65**) has subjected Heine's conclusion to experimental analysis by having 5 widely varying degrees of learning: 6, 11, 16, 21, and 26 repetitions of lists of 9 nonsense syllables learned by the anticipation method. A rest and a work condition for each of the 5 degrees of learning were compared. In the work condition the interval between learning and relearning was filled by a constant interpolation of 11 repetitions of a second list of 9 syllables. In the results, the overlearning ratios showed that the increase in number of presentations meant a corresponding increase in degree of learning. Taking this into consideration, the relative amount of retroactive inhibition, measured in terms of both recall and relearning scores, varied inversely as the number of presentations given the original material. In other words, there was a tendency throughout for retroaction to decrease as degree of learning increased. This was the relationship suggested by Heine, and indicated by the results of Robinson and Heron, and Robinson and Darrow: the greater the degree of original learning, the less is the probability of retroactive inhibition. In McGeoch's experiment this tendency applied even to the serial

positions in the list differentially; that is, the position of the maximum amount of inhibition shifted as the degree of learning increased.[29]

A recent study by Britt and Bunch (**10**) has a bearing on the factor of degree of original learning. These investigators were studying the relationship of Jost's Law and retroactive inhibition, and wished to determine which of two associations of the same strength but of different ages is the more susceptible to retroactive inhibition. Jost's Law states that, of two associations of equal strength but of unequal age, the older association is more increased in strength by new repetitions than the younger. Does it follow that this older association is also less susceptible to retroactive inhibition?

Using 120 subjects, 30 in each group, the following experimental procedure was employed:

Group	Learning	Interval	Conditions employed to reach level of complete mastery	Conditions of interpolated interval	Retention
I	Maze I	48 days	Maze I (Relearning)	Maze II	Maze I
II	Maze I	48 days	Maze I (Relearning)	20-min. rest	Maze I
III			Maze I (Learning)	Maze II	Maze I
IV			Maze I (Learning)	20-min. rest	Maze I

The twenty-minute period of rest was filled by reading and noting jokes in a humorous magazine.

In terms of time, trials, and errors, and on the basis of relearning, recall, and saving scores, the relative amount of retroactive inhibition in the older age-groups, Group I and II, was consistently far less than the relative amount of retroactive inhibition in the younger age-groups, Groups III and IV. Hence, these investigators conclude that, "of two associations (maze habits) of equal strength but of unequal age, the younger is more susceptible to retroactive inhibition". Their experiment illustrates a greater degree of learning in the case of the older associations, and a corresponding decrease in susceptibility to retroactive inhibition.[30]

(*b*) *Overlearning.* In McGeoch's (**65**) experiment (above), even when the number of presentations of the original material was as high as 26, with the consequent overlearning, the amount of retroactive inhibition was 46.2% in terms of recall score and 5.3% in

[29] Elsewhere (**66**) McGeoch notes "that the smallest amounts of retroaction come toward the end of the list among the positions relatively less favored in learning, thus reversing the principle, which holds for total lists, that degree of retroaction varies inversely as the degree of learning".

Also note the degree of learning as a possible explanatory factor of the differences in results as to the time interval (**73, 74**; *cf.* **79, 80**).

[30] Degree of learning also seems to be an important factor in Sackett's (**110**) study.

terms of saving score. This showed that a high degree of overlearning did not protect nonsense syllables from the inhibiting effects of other syllables.

One other study, by Bunch and Wientge (14), has also considered the factor of overlearning. These investigators showed that pleasant lists of words, on the average, were not as susceptible to the retroactive effect of interpolated indifferent lists as were unpleasant lists; and that indifferent lists were more susceptible to retroaction than unpleasant lists, according to relearning and recall scores, but that unpleasant lists were more susceptible to retroaction than indifferent ones according to per cent saving scores. In the original learning, the pleasant material had the greatest overlearning ratio, then the indifferent material, and last the unpleasant material, although the difference in overlearning between the indifferent and unpleasant material was small. Consequently, along with other factors, this degree of overlearning is suggested as a possible explanation.

(6) *The Amount of Material for the* INTERPOLATED *Activity.* This has not been the sole variable in any experiment thus far, but is definitely related to the next factor to be considered.[81]

(7) *The Degree of Learning of the* INTERPOLATED *Activity.* Only one investigator to date, McGeoch, has devoted an entire study to this factor, but it has been important in certain earlier investigations.[82] McGeoch (71, 97) reported 2 experiments on the influence

[81] However, Vélinsky (130) conducted some experiments in which he presented series of calculations such as: 17×56=253; 17×56=835. By using such arbitrary products, he hoped to avoid the effects of previous association. In each series the product was to be associated with the particular arithmetical statement, but the two were divided by an interval during which indifferent products were presented. In some cases the interval remained constant and the interpolated material varied, while in other cases the interpolated material was constant and the interval was varied. It was found that the number of interpolated units had little effect. As the length of the interval increased, however, the number of repetitions necessary for learning also increased.

[82] With a "long" interval of interpolated learning, a "short" interval of interpolated learning, and an "empty" interval of approximately the same length as the "short" interval, Foucault (26) found decreased forgetting in the order named. This might be interpreted as indicative, although certainly not conclusive, that a lesser degree of interpolated learning is associated with less retroaction of the original material.

Webb (134) maintained: "The degree of retroaction is a function of the interpolated maze activity. The easier is the maze to learn, the greater is the resulting negative retroaction."

Ho (42) found that varying amounts of practice by *rats* in an interpolated maze over a period of 20 days exerted a distinctly *favorable* effect upon retention of the original maze problem, and that the degree of facilitation tended to vary slightly with the amount of practice.

of *interpolated* learning upon retroactive inhibition, and thus made a logical extension of his previous work (**65**), which demonstrated that retroaction varied inversely as the number of presentations given the *original* material.

As before, it was assumed that degree of learning increased with increasing frequency of presentation, and this assumption was borne out in terms of correct anticipations. In the first experiment of this later study, the same lists of 9 nonsense syllables were used as in the earlier study, and the anticipation method was employed with 12 subjects. In the previous study the original lists had been given 6, 11, 16, 21, and 26 presentations, and the interpolation had consisted of a work condition of 11 constant repetitions of a second list, or of a rest condition. In the present experiment the situation was reversed, for the number of repetitions given the original list was held constant at 11 repetitions, and the interpolated lists were given either 6, 11, 16, 21, or 26 repetitions. The "rest" condition was filled by reading and marking humorous stories for 10 minutes. Under the 5 work conditions, of from 6 to 26 presentations, whatever portion of the ten-minute interval was not occupied by these presentations was filled as under the rest condition.

The resulting data revealed that 6 repetitions of an interpolated list produced a large degree of retroactive inhibition, but a degree which was smaller than that which resulted from numbers of repetitions from 11 to 26. These frequencies, of 11, 16, 21, and 26, yielded virtually the same amounts of inhibition. McGeoch says: "When interpolated learning is slight, it appears that retroaction is a function of degree of learning, but that as complete mastery is approached and passed, additional increments have no observable effect."

In the second experiment of the study, the method of complete presentation was employed with 42 subjects, using lists of nonsense syllables.

In the "rest" condition, a list was studied for 120 seconds, followed by 45 seconds of recall, followed by 5 minutes of rest (reading and marking jokes), with a final 45 seconds for a second recall. In the work condition, a list was also studied for 120 seconds and a recall was taken for 45 seconds; but a second list was then immediately given for learning, and the time allowed for this interpolated learning was varied—60, 90, 120, 150, and 180 seconds—so that there were 5 different conditions of work. At the conclusion of the interpolated learning, there were 45 seconds for a recall of this second list studied, followed by the reading of jokes for the remainder of the 5 minutes, at the end of which time there was a second recall of the original list.

The percentages of recall showed a steady decrease in recall, that is, a steady increase in retroactive inhibition, from 60 to 150 seconds of interpolated learning, but the differences involved were not statis-

tically reliable. There was also a decrease in inhibition from 150 to 180 seconds which was not established statistically; but it suggested to McGeoch that perhaps amounts of time over 150 seconds for interpolated learning might be associated with decreasing degree of retroaction. To test this possibility, a check experiment was carried out with 15 subjects, using the same lists and the same experimental procedure. There were 3 conditions: a rest condition, and 2 work conditions, one with interpolated learning of 150 seconds, and the other with interpolated learning of 240 seconds. Although the differences found were statistically unreliable, the tendency was the same as that found in the principal experiment.[38]

The relationship between amount of inhibition and amount of interpolated activity has been mentioned by Bunch and McTeer (13), and by Britt and Bunch (10). Bunch and McTeer found that punishment for errors during the interpolated maze problem resulted in quicker learning of that problem than when there was no punishment during the interpolated problem, and also that there was less susceptibility to retroactive inhibition under the former condition. Hence, they say: "It is possible that the amount of maze activity indulged in during the retention interval may be causally related to the interference which it exerts upon a previously acquired maze solution in such a way that a significant decrease in the amount of such interpolated activity is followed by better retention than would occur without such a decrease." Britt and Bunch found the older of two associations (maze habits) of equal strength but of unequal age to be less susceptible to retroactive inhibition than the younger. However, the interpolated maze problem was learned in less time, in fewer trials, and with fewer errors by the group with the older associations than by the group with the younger associations. The interpolated problem was the same for the two groups, but obviously the amount of interpolated maze activity was not, and this is mentioned as one of the possible explanations of the results.

[38] Under the conditions of their experiment, Siipola and Israel (112) found "that the stage of habit-formation, the 'mere strength' of the organization, can be a determinant of interference both as to its degree of effectiveness and as to the time of its occurrence. . . ." They then note that an analysis of McGeoch's (71) results "reveals a tendency for the maximal retroactive effect to occur when the interpolated task has been learned to about the same degree as the original task. This suggests the possibility that the general law indicated by the present study of interference may apply also to retroactive inhibition."

(8) *The Amount of Practice (Previous Experience) with the Material.* A factor closely related to degree of learning (of original or of interpolated material) is that of *practice* with the learning material—practice, in the sense of previous experience. Several investigators mention the fact that they have tried to control this variable by introducing practice periods previous to the actual experimental sessions, but only a few discuss its probable relationship to retroactive inhibition.

The results of Robinson (103) and of Skaggs (113) seem contradictory. Robinson noted both in the third part of his experiment, with a practiced chess player, and in the fourth part, using three-place numbers, "that one who is accustomed to dealing with a given material may not be as susceptible to retroactive effects, so far as that material is concerned, as one who has not had such past experience". On the other hand, Skaggs, in the case of sense words, found an indication that as the subject became more practiced, there was an actual increase in the detrimental effect of the work material. His results on this point in the reconstruction tests were conflicting. However, Skaggs has since stated (116): "Practice with any material seems to tend to reduce the influence of the factors making for retroaction."

McGeoch (71) compared the amount of retroactive inhibition found in the first and the second experimental cycles. He says: "The influence of practice at the experimental conditions under which retroaction is being measured is a function of the method of measuring retention and of the list the frequency of which is varied.[34] When the frequency of the interpolated list is varied, inhibition in terms of recall shows no effect, while that in terms of relearning decreases strikingly from cycle to cycle. When the frequency of the original list is varied, recall shows a practice effect while relearning does not." [35]

Bunch and Wientge (14), who found pleasant material less susceptible to retroactive inhibition than either indifferent or unpleasant material, mention the degree of learning prior to the test as one of the possible explanations of their results. The fact that original learning scores were best for the pleasant material might suggest that

[34] Also, *cf.* McGeoch (65).

[35] McGeoch has since used data from this same experiment (71) in order to study the changes accompanying practice upon successive samples of verbal material (75), and the data from another experiment (74) to study curves of memorization after different amounts of practice (76).

the pleasant material was already better known to the subjects than the other material.[36]

The work of Britt and Bunch (10) tends to confirm the findings of Robinson and of McGeoch, that increased practice is associated with less susceptibility to retroactive inhibition.

In their experiment, the older age-group had more practice with the original learning material than the younger age-group and showed less susceptibility to retroactive inhibition. However, they say that "this does not mean that the older of two associations of equal strength is more resistant, by virtue of its age, to the detrimental effects of activities learned subsequently. To state that the age of the original habit is greater in one group than in the other, at the time of the interpolated acquisition, is very probably nothing more than a convenient way of calling attention to the fact that the retentive process underlying the habit has been subjected to such things as greater amount of activity and different sequence of events. Whenever the age-factor in such a situation is varied, as in the present instance, other factors are also necessarily varied, such as distribution of effort, amount of practice, and familiarity with the test situation. These factors are probably of great importance in accounting for the relationship that has been found between the age of the associations and susceptibility to retroaction."

After a seven-day interval, McGeoch and McKinney found less retroaction with poetry (79) when there had been an intermediate recall 15 minutes after interpolation than when there had been none, but did not find this relation in the case of prose (80).

(9) *Diurnal Variations and Fatigue.*[37] One of the 4 sets of conditions studied by Tolman (127) was that of efficient *vs.* inefficient working periods. Lists of nonsense syllables which were learned in the morning were compared with similar lists learned immediately after the noon meal or in the evening. Greater inhibition was shown for the afternoon and evening lists. In other words, Tolman found a more detrimental influence of work upon learning in the evening than in the morning.

[36] These investigators, however, call attention to the fact "that all words used in this experiment were well known to the subjects, and inequalities in the degree of familiarity with the material would probably be of less significance in this case because of the great amount of overlearning". Also, "it is unlikely that any particular series used was favored greatly over any other on the basis of prior learning and especially unlikely that all series of pleasant words were favored in this respect over the series of indifferent and unpleasant words".

[37] Finkenbinder (25) was one of the first to attempt to control the factor of diurnal variation in learning performance. Also, *cf.* Leuba and Hyde (57), Radosavljevich (100), Bean (4), Spight (120), Boreas (7), and van Ormer (128, 129).

Skaggs (113) carried out experiments similar to Tolman's, but did not confirm his conclusions. His data did not consistently indicate that the amount of retroactive inhibition varies with the time of day, and he suggested rather that the work activity acts relatively more detrimentally upon original learning as the subject becomes more and more fatigued.

(10) *Intervals of Sleep Compared with Intervals of Waking.* Since a comprehensive review of the experimental literature on the topic of sleep and retention has recently been published by van Ormer (129), there is no need of duplication here.

The following studies, which are discussed by van Ormer, have a definite relation to the subject of retroactive inhibition: Ebbinghaus (23), Radosavljevich (100), Bean (4), Finkenbinder (25), Foucault (26), Heine (39), Nicolai (93), Luh (59), Jenkins and Dallenbach (53), Dahl (19), Spight (120), Boreas (7), van Ormer (128), Hunter (48).[38] Van Ormer (129) says that ". . . the conclusion seems established that the usual amount of daily sleep (about 8 hours) favors retention of nonsense syllables over that time interval". As to whether "retention of nonsense syllables is better *even after short time intervals of sleep* than it is after the same intervals of waking, the results are conflicting. Jenkins and Dallenbach's, Dahl's, and van Ormer's results warrant the conclusion that retention of nonsense syllables is better after 4 hours of sleep than it is after 4 hours of waking. The first and last of the three studies suggest that the advantage of sleep is not as great at 4 as at 8 hours. It is apparent that more study of the 1- and 2-hour periods is desirable. . . ." [39]

(11) *Mental Set; Hypnosis; Suggestion.* (*a*) In Whitely's second experiment (137), the results tended to show that the "set" with which the subjects approach the original learning material influ-

[38] A study not included in van Ormer's review is that by Leuba and Hyde (57) in 1905. The task of the subjects was "to put English prose into German script and to write in English script English prose which they had before them in German script". In part of the experiment the sessions, 1 hour in length, were at 8:40 A.M., and at 1:40 P.M. "An interval of four hours, filled with varied intellectual work and much taking of lecture notes, had elapsed between the morning and the afternoon exercises, while twenty hours, including the night's rest, separated the morning from the preceding afternoon's practice." In almost every case there was a considerable gain in progress in the morning and only a small one, sometimes even a loss, in the afternoon.

[39] Purdy (99) has made the following suggestion: "It is possible that the low retroactive effect associated with a period of sleep depends upon the joint presence of two factors: a low level of activity, and an instability of the *new traces* produced by such activity. Immediate memory is poor in the hypnagogic state, and it is notorious that dreams are easily forgotten. Activities occurring during sleep which left no new traces behind would presumably have no retroactive influence."

ences the degree of retention. Whitely presented an association test in a particular field so as to bring into action the associative systems which might belong to that field; this situation was designated " the arousal of an apperceptive set ". This aroused set was considered " congruous " when it was in the same field as the material which was to be learned. The experimental data indicated that the arousal of an apperceptive set immediately preceding learning exerted a detrimental influence on recall 24 or 28 hours later, and that the interference was greater when the set was congruous.

Lester (56) conducted an experiment in order to find the effect of " set ". " Set " was defined by her as " that mental attitude which is the result of specific work instructions, and which may or may not involve changes in muscular tonus, or the assumption of any particular bodily attitude, on the subject's part ".

Two hundred subjects were used, and the learning materials, both original and interpolated, were lists of 12 three-letter nonsense syllables. Twenty-four hours elapsed between learning and recall, and the interpolated material was introduced immediately before recall. Written directions were given to the subjects at the time of original learning, and these directions differed as to amount of information given about the experiment: (1) expectation of a recall, (2) expectation of an interpolated list, (3) information in regard to the possible effects of an interpolated list, (4) directions urging the subject to make an effort to avoid the possible interference effects of the interpolated list.

With any one or all of the first 3 conditions the retroactive effects were very definitely minimized. There was a consistent trend in the data which suggested that increasing amounts of information given at the time of learning resulted in decreasing amounts of retroaction; but the differences, considered individually, were not statistically significant. With the fourth condition there was significantly less retroactive inhibition than under any of the other conditions. "All conditions differed significantly from the one in which no information was given, and in which an interpolated list of nonsense material was introduced, *i.e.*, the condition which demonstrated the retroactive effects unaffected by directions of any sort." Hence, the principal conclusion of the experiment was that retroactive inhibition is minimized by directions establishing a set or attitude at the time of learning.

(*b*) In any experimental work on hypnosis and learning in which a trance state is employed before retention test, this interpolation necessarily introduces the problem of retroactive inhibition. In this sense, there are several studies of hypnosis which involve the ques-

tion of retroaction.[40] Mitchell (85), however, is the first to make a systematic study of hypnosis in its direct relation to retroactive inhibition.

In the first project of her study she wished to determine whether or not retroaction occurs, when the original and interpolated material are learned in different states (waking and trance). The anticipation method was employed with 2 subjects, with lists of 10 three-place numbers for both the original and interpolated learning. The experiment was divided into 2 parts. In the first part the subjects learned the first list in the waking state, the second list in the trance state, and relearned the first list in the waking state, with the control situation of learning both lists and relearning the first list in the waking state. The second part was the direct opposite of the first; that is, the subjects had original learning in the trance state, interpolated learning in the waking state, and relearning in the trance state, with the control situation of all learning and relearning in the trance state. Whenever the learning was done in the trance state, the subjects, before being awakened, were given the suggestion of post-hypnotic amnesia for everything that had happened during the trance. The data tended to show that "learning the interpolated list of numbers in a changed state, either waking or trance, causes more interference in the recall of the list, than learning them in the same state".

In the second experiment reported in the same article, Mitchell tested "the power of memory in hypnosis for material recently acquired as compared with memory in the waking state for this material".

The same type of material and the same 2 subjects were used. There were 4 different learning conditions: (1) learning the first list in the waking state,

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[40] Jenkins and Dallenbach (53) had a subject learn nonsense syllables while hypnotized; after being brought out of the hypnotic state he continued his daily duties and then was hypnotized again for the retention test. Recall was perfect after intervals of 2, 4, and 8 hours, and was 80% perfect after 24 hours (approximately 8 hours spent in sleep).

With paired associates for learning material, Young (140) tested 15 hypnotic subjects for recall in trance and waking states, and 4 non-hypnotic subjects in relaxed and waking states, and found slightly poorer retention scores for the waking state. In another experiment (141), however, with a test of 2 subjects on recall of objects casually observed, the trance state showed no advantage over the waking state.

Huse (51), employing 8 subjects, had them learn nonsense material in the waking state, and recall in the waking and in the trance states after an interval of 24 hours. Although her data showed slightly more recall in the waking state, she concludes: "There is probably no significant difference between recall in the trance and normal states of nonsense-material after learning."

Stalnaker and Riddle (121), with 12 subjects, found hypermnesia in the trance state for sense material learned a year or more before; the subjects, however, were given a suggestion in the trance state as to improved recall.

reading for 7 minutes, and taking a retention test in the waking state; (2) learning the first list, learning the second list, and relearning the first list, all in the waking state; (3) learning the first list in the waking state, reading for 5 minutes (plus 2 minutes more for hypnosis), and relearning the first list in the trance state; (4) learning the first list in the waking state, the second list in the waking state, and relearning the first list in the trance state. The principal comparison was between conditions (1) and (3), and between conditions (2) and (4). In terms of saving in trials, saving in errors, and recall, there was no improvement in retention in the trance state, as compared with the waking state.[41]

(*c*) An experiment was next undertaken by Mitchell (**86**) in an "attempt to inhibit retroactive inhibition by waking suggestion".

Lists of 10 three-place numbers were again used, and 11 subjects took part in the experiment. There was a practice period of from 8 to 11 days, during which it was attempted to train the subjects to be suggestible to the experimenter. This was done by suggestions that the hands were stuck together, that the feet were stuck to the floor, that the legs were stuck in a crossed position, etc. Also, the attempt was made to eliminate practice effects by having the subjects learn 2 lists of numbers each day during this same period. Following these days of training, 2 lists were learned and the first relearned at each experimental session, with suggestions preceding each memorization. There were 2 experimental conditions. Under the first condition, the suggestions were given before learning the first list that it would be easily forgotten; before learning the second list that, after it was learned, the first list would be completely forgotten; and before relearning the first list that it could not be remembered. Under the second condition, the suggestions were given before learning the first list that it would be remembered well, even after learning another list; before learning the second list that, after learning it, the first list would still be remembered; and before relearning the first list, that it could be remembered.

In terms of trials and errors in learning the lists, overlearning scores, recall scores, and saving in terms of trials and errors, there were no consistent nor reliable differences between the two conditions. Even in the subjects who had previously responded to suggestions of muscular contraction, recall scores were not materially affected.

Another experiment, somewhat similar in nature, has also been reported by Mitchell (**87**).

Again, with 11 subjects, the anticipation method was employed with lists of 10 three-place numbers. The subjects learned the first list, after 40 seconds learned the second list, and then after another 40 seconds relearned the first list. Immediately preceding each list, the subjects were given suggestions as to the efficacy of retroactive inhibition. In the first condition, the direct sug-

[41] For additional consideration of these experiments, see Hull (**44**).

gestion was given that the subject *would not* be able to remember the first list after learning the second. In the second condition, the direct suggestion was given that the subject *would* be able to remember the first list after learning the second. The practical identity of the results in the 2 conditions is shown by the fact that the gross number of errors for the second condition was 99.5 per cent of those for the first condition.

(12) *The Nature of the Learning Material.* (*a*) *Verbal and Motor Material.* Retroactive inhibition has been demonstrated for verbal material, *e.g.,* Müller and Pilzecker (**89**), and Robinson (**106**); and for motor material, *e.g.,* Webb (**134**), and Britt and Bunch (**10**).

(*b*) *Sense and "Nonsense" Material.* Retroaction has also been demonstrated for sense material, *e.g.,* Skaggs (**113**), and Johnson (**54**); and for "nonsense" material, *e.g.,* Heine (**39**), and McGeoch (**65**).

(*c*) *Meaningful (Interrelated) Material.*[42] The studies by McGeoch and McKinney (**79, 80**) have been particularly concerned with this factor.[43] They reached the following conclusions: "The amount of inhibition found with the prose, when other prose is interpolated, is less than that found with poetry, when other poetry is interpolated and when the scoring is in terms of meaning correct or of meaning partially correct. The prose is roughly equal to the poetry in susceptibility to inhibition when the poetry is scored in terms of lines verbally correct. Since all scores must be considered in evaluating the results with the poetry and since the retroactive effect is in one sense the total of all, it must be concluded that prose is less susceptible to inhibition than is poetry under the conditions of these experiments. This is especially true after the 7-day interval and still more so when the recall after 15 min. has been omitted" (**80**).[44]

(*d*) *The Affective Nature of the Learning Material.* Another set of conditions studied by Tolman (**127**) was concerned with the affective nature of the learning material. In general, he compared the susceptibility of pleasant and indifferent materials to retroactive interference, using word lists or lists made up of numbers and words.

[42] This might also be referred to as, "degree of organization of the material".

[43] Other experiments, *e.g.,* those of Dreis (**22**) and of Gengerelli (**33**), have shown retroaction with other types of meaningful material. Also, *cf.* the use of poetry and prose by Sleight (**118**), of *detached* and *associated* words by Tait (**125**), and of poetry by Boreas (**7**).

[44] The finding of greater susceptibility of poetry (**79**) and of prose (**80**) to retroaction after 7 days than after 15 minutes differed from the finding with lists of adjectives (**73, 74**) of no consistent variation in retroaction with time interval.

The lists were pleasant or indifferent according to the judgments of a number of persons, on the basis of the words which they contained. His results showed less inhibition for the pleasant lists than for the indifferent lists.

Bunch and Wientge (14) wished to find the relative susceptibility of pleasant, unpleasant, and indifferent material to retroactive inhibition, with indifferent material for interpolated learning.

The learning material for each subject was a list of 15 words, and a separate list was prepared for each subject. The particular words for each individual were selected from a larger list of words in a preliminary study, "on the basis of (1) the subject's judgment of each word as to its affective value, and (2) the subject's reaction to each word as registered by a Hathaway galvanometer". The anticipation method was employed throughout, and there were 6 groups of approximately 21 subjects each. Three groups learned pleasant, indifferent, and unpleasant material respectively, and took retention tests 48 hours later. The other 3 groups also learned pleasant, indifferent, and unpleasant lists respectively, but learned a second list, of indifferent material, after the 48 hours and just before the retention test of the original material.

The results showed that the learning of indifferent material had a detrimental effect on the ability to retain all 3 types of material. They also indicated that the amount of retroaction "is to some extent a function of the affective tone of the originally learned material". In terms of per cent saved the greatest amount of retroactive inhibition was with the unpleasant material; in terms of relearning and recall scores, the greatest amount was with the indifferent material; and, according to all the criteria of measurement employed, the least amount of retroaction occurred for the pleasant material.

(13) *Electric Shock, Emotional, or Sensory Disturbance Before or During* ORIGINAL *Learning.* (*a*) *Electric Shock.* Bunch and McTeer (13) attempted to find out if retroactive inhibition is greater or less when original learning is given under punishment conditions. Two stylus mazes were used with 100 subjects, and electric shock (27 volts A.C.) served for punishment of certain errors. The following table (in which S=shock or punishment, and N=normal or non-punishment) shows their experimental procedure:

	First maze		Second maze		Relearning
1.	N	3 weeks	N	3 weeks	N
2.	N	3 weeks	S	3 weeks	N
3.	S	3 weeks	N	3 weeks	N
4.	N		6 weeks		N
5.	S		6 weeks		N

With punishment during original learning, as compared with normal non-punishment learning, they found that the amount of retroactive inhibition, except in terms of trials, was reduced by one-half. Further, when the interpolated problem was learned under conditions of punishment, while the original learning was under normal conditions, the amount of inhibition, except as to trials, was also decreased approximately one-half.

(*b*) *Emotional or Sensory Disturbance.* 1. *Human Subjects.* Tait (**125**) introduced such factors as ringing a bell, pistol shot, odor, rotation, in the middle of reading of a list of words. He noted, in general, that the sudden disturbances often seemed to efface what had gone before but to reinforce what came afterward.

Another of the variables studied by Tolman (**127**) was that of "normal *vs.* distracted attention". The subject learned lists of alternate nonsense syllables and words. Under the conditions of "distracted" attention, a telegraph key clicked 1, 2, or 3 times as each pair was shown, and the subject duplicated the taps by striking the table with a pencil. No greater evidence of retroactive inhibition was shown for this condition than for the condition of normal attention.

Another part of Tolman's study (**127**) was concerned with the amount of retroactive inhibition when the subject received caffeine as compared with the amount of inhibition when he received no caffeine. The subject took 1½-grain capsules of caffeine on alternate days and took sugar-of-milk capsules on the days in between, but did not know which capsules contained caffeine and which did not. Although the differences were small, there was some evidence for greater inhibition on the non-caffeine days.

2. *Animals.* In some of Lashley's (**55**) experiments on retention, both the normal rats and the cortically damaged rats had the learning of the 3 culs-de-sac maze, the 1 cul-de-sac maze, and the brightness-discrimination problem interpolated between the original learning and retention test of the 8 culs-de-sac maze. There was also interpolated learning between original learning and relearning of the 1 cul-de-sac maze and of the Yerkes discrimination box. The normal rats made relatively better scores on the retention tests. However, whether these results show that the amount of retroaction, or mere retention (if the two can be separated), is detrimentally affected by cortical injury remains an open question. As Melton (**83**) has pointed out, Lashley has assumed that any differences in performance in the experimental and control groups are necessarily due to the modification of the factor of retentiveness. "This in turn implies either that

susceptibility to retroactive inhibition is not influenced by cortical damage, or that there is a high positive correlation between susceptibility to retroactive inhibition and retentiveness. Neither of these implications have definite experimental proof."

(14) INTERPOLATED *Electric Shock, Emotional, or Sensory Disturbance.* (*a*) *Electric Shock.* Both Harden (**38**) and McGeoch (**69**) found slight indications of retroaction from the interpolation of reading plus shock. White (**135**) presented a list of 15 three-letter nouns once to each of 30 subjects, after which the subject either was given an electric shock (with galvanic deflection recorded) and then read for 12 minutes or else read immediately for 12 minutes. After a recall test he read for 5 minutes, and then the above procedure was repeated until each subject had seen 4 lists after 2 of which he was shocked. White found that shock facilitated recall in 13 subjects, hindered recall in 15 subjects, and had no effect on 2 subjects. "Relatively small changes in galvanic resistance accompanied a loss in recall and relatively large changes in galvanic resistance accompanied a gain in recall."

(*b*) *Emotional or Sensory Disturbance.* 1. *Human Subjects.* Many different situations were varied in Tait's (**125**) study, and the following are typical illustrations:

> Lists of *detached* sense words were read to the subject, and the time interval before retest was 1 minute, except in the case of the pistol shot. During this interval, a disagreeable odor, sudden ringing of a bell, or a pistol shot was introduced. In almost all cases the list of words was entirely forgotten. In another experiment, however, with lists of *associated* words, the bell and the odor made very little difference, but the pistol shot exerted a detrimental effect. Disturbances introduced in the middle of a list did not have as destructive an effect as when they came at the end. In another part of the study, lists of "indifferent" words were read to the subjects. Following one list something "pleasant, optimistic, and cheerful" was read to them, and after another something "unpleasant and depressing". Working for a period of 3 weeks with 11 subjects, it was found that the average percentage of words remembered under the former condition was 21%, and under the latter condition was only 15%.

In a study by Harden (**38**), 3 experiments employed nonsense syllables for the original material. Five different interpolated activities were used: (1) reading silently with lip movement (control); (2) reading aloud from a humorous selection; (3) reading with noise and flash; (4) reading with electric shock; and (5) reading silently with electric shock or threatened shock, loss of bodily support, and noise. She found a slightly greater average loss in all of the test

experiments, which fact seemed to her to point to some emotional interference. All differences between control and test records, however, were small, and none of them was statistically reliable.

The "retroactive" effect of pleasant and unpleasant odors upon previously learned material has been studied by Frank and Ludvigh (**30**). Lists of 10 pairs of nonsense syllables were repeated 10 times for each of 12 subjects. Immediately following learning, 6 pleasant, unpleasant, or indifferent odors were experienced, then a ten-minute period of reading, and finally the retention test for the syllables. It was concluded that pleasant odors had a "retroactive facilitative effect" as compared with the influence of indifferent odors, while unpleasant odors had a "retroactive inhibitory effect", and further that the degree of retroaction was proportional to the degree of pleasantness or unpleasantness of the odor as judged by the subject.

2. *Animals.* The Jenkins and Dallenbach (**53**) experiment on sleep suggested to Hunter (**48**) the study of the effect of inactivity produced by cold upon learning and retention of a darkness-avoiding response by the cockroach. "Animals so inactivized learned more slowly and retained more poorly than animals who had spent the corresponding periods in normal temperatures and at normal activities"(**49**). Hunter notes, however, that inactivity due to cold may not have the same relation to retention as inactivity due to sleep (**48**).

Tirala (**126**) found that bees required 3 days or more to return to their hive after etherization. Rösch-Berger (**109**) suggests that this was because the bees had not become oriented in the vicinity previous to the experiment; he repeated the experiment with older and well-oriented bees, and neither a period in the refrigerator nor etherization prevented their return to the hive within 15 minutes after release.

(15) *Transfer of Training.* Webb (**134**) concluded: "There is a negative correlation between positive transfer and negative retroaction. Those conditions which produce the maximum amount of positive transfer give the least amount of negative retroaction." Under the conditions of their experiments, Bunch and McTeer (**13**), and Britt and Bunch (**10**),[45] found suggestions of a similar relationship.[46]

[45] *Cf.* Britt (**9**).

[46] Maslow (**61**) notes that the originally learned material in a retroaction experiment may also have a deleterious effect on interpolated learning, that

(16) *Retroactive Inhibition Within a Series.*[47] Foucault (29) in 1928 interpreted certain phases of the serial position curve in terms of retroaction. He maintained that in a series of words to be memorized, the first has its "image" partly inhibited by the second, the second by the third, etc.; this is similar to retroactive inhibition except that the inhibiting factors are within the series itself, and he calls this "regressive internal inhibition". Also, as the word-series is increased in length, the difficulty of memorizing new words is more and more increased, due to the number of antecedent images to be inhibited, and this is called "progressive internal inhibition".[48]

With 100 children as subjects, Foucault secured the type of serial position curve which he had posited.

Other investigators have also made references in some way to retroaction within a series. Using series of "visually perceived forms", Gibson's (35) observers objected that the appearance of each succeeding figure "blotted out" the preceding one, so that on completion only the last one or two could be remembered. McGeoch (65, 66) found that retroactive inhibition affects serial positions differentially.[49] Mitchell (87) says, with regard to the memorization of numbers: "The tremendous influence of the next number found throughout all the verbal responses may be described as a form of retroactive inhibition within the list."

(17) *Subjects.* (*a*) *Adults.* The majority of experiments demonstrating retroaction have used college students and adults as subjects. The amount of retroaction varies from one individual to another, but there have been no indications that the amount is a function of sex differences.

(*b*) *Children.* Only a few investigators have used young children in experiments involving retroactive inhibition. Hinrich (41), who used 10 children 9 to 13 years old as subjects, employed one-syllable substantives for original learning, and concluded that he had demonstrated "auch bei Kindern eine ziemlich bedeutende rückwirkende Hemmung nachzuweisen ist". An analysis of Whitely's (137) data,

"the process may be not merely retroactive inhibition, but rather mutual interference".

Gengerelli (33) says: "Interpolated tasks, bearing a resemblance to the original not greater than .73, effect a certain amount of positive transfer which varies directly as the degree of resemblance between the original and interpolated task."

[47] Also, *cf.* Tait (125) above.

[48] Stevanović (122) had noted "retroactive" and "anticipatory" influences in a series of pictures to be learned.

[49] See section (5) above, *The Degree of Learning of the* ORIGINAL *Activity.*

on students in college, high school, and grade school, revealed that the influence of prior intellectual activities upon recall was not a function of the age or of the school standing of the subjects. Foucault (29) found "regressive internal inhibition" with children as subjects.

In order to determine the importance of age as a differentiating factor, Dreis (22) has studied the susceptibility to retroaction at various grade levels. She employed the same substitution test for original learning as in her study of the factor of similarity, and used interpolated material with all the elements comparatively dissimilar to the original material. Scores of 672 pupils from Grades 2A through 8A of an elementary school system were collected. In general, there was relatively the same degree of susceptibility to retroactive inhibition in all grades, and apparently no increase or decrease of susceptibility with age.[50]

(*c*) *Rats.* Comparatively few studies involving a retroactive "set-up" have used rats as subjects, and some of these have not shown evidence of retroaction.

Hunter (45, 46) and Hunter and Yarbrough (50), found little evidence of interference in retention of an auditory-discrimination habit. Brockbank (11), who introduced a rope-ladder problem between the learning and relearning of a maze by rats, found no evidence of retroaction. Ho's (42) data not only showed no marked retroaction, but even showed facilitation from interpolation.

Other investigators, however, have presented evidence of retroactive inhibition in rats.

Pechstein (95), who trained rats in 4 units of his maze and then had them relearn the first unit, says: "The data are indicative of retro-active inhibition". Webb (134), who used mazes both for original and interpolated learning, found susceptibility to retroaction in rats, but says: "Human subjects are more susceptible than rats to the disintegrating effect of retroactive influences." Wiltbank (139) retested rats on a maze after an interval during which 4 other mazes had been learned, and found a general lack of saving, but his data do not show whether or not this was due only to this additional maze activity.[51]

(*d*) *Other Animals.* Interference effects have been demonstrated with cockroaches (48), and with one group of bees (126) but not with another group (109).

(18) *Methods of Measurement.* (*a*) *Method of Recognition.* Heine (39) found no evidence of retroactive inhibition when the

[50] Part of the subjects of Radosavljevich (100), Nicolai (93), Dashiell (20), and McGeoch (66) were children.

[51] Experiments on rats by Dashiell (20), Lashley (55), and Bunch and Magdsick (12) also have a relation to the problem of retroactive inhibition.

method of recognition was employed; and, according to Hollingworth (43), Müller reported "that retroactive inhibition fails to appear if partially learned material, followed by some different task, is merely recognized". Certain contradictory evidence, however, is found in the work of Strong, of Lund, and of Dahl. Strong (124) used the recognition method with advertisements. "One group . . . saw four magazines one right after the other. The other group saw the same four magazines after intervals of one month. Both groups were tested four months after the first magazine was seen in each case . . . the second arrangement is better than the first."

With 4 fairly large groups of subjects, Lund (60) used 3 lists of five-letter nonsense words in a fall tachistoscope, the second list differing from the first only in that *1* letter had been changed in every word, and the third list only in that *2* letters had been changed. The words of the first list were presented at ten-second intervals, and later, when presented for recognition, were given with those of the other two lists. Lund found false responses and lack of recognition, and explained his results "as due to retroactive effects".[52]

Dahl (19) found better retention after a period of sleep than after one of waking when retention was tested by the recognition method.

McKinney (82), however, was the first to report an experiment devoted entirely to the question of retroaction in the case of recognition memory. One group of 26 subjects observed nonsense syllables, and two other groups, of 50 and 56 subjects respectively, observed advertisements. "The same type of material was used as interpolation as was observed originally in each case", and the original materials were then identified from among a larger group. Small but consistent amounts of retroaction were found for both types of material.

Gibson (36) has also demonstrated that retroactive inhibition may appear when retention is tested by the recognition method. Lund's (60) first list of words was used for original learning material with 40 subjects. During the interpolated period of 5 minutes, half of the subjects learned or partly learned another list of five-letter nonsense words, like those of the first list "but bearing no specific

[52] He says that "there can hardly be any doubt as to the presence of retroactive effects in recognition, or that the basis of recognition and recall, contrary to Müller's assertion, is different in any important aspects. The fact that recognition is less efficient when a large number of objects is presented than when a smaller number, as well as the fact that a lapse of time between presentations makes a difference, should be sufficient to demonstrate retroactive effects."

resemblance to them", while the other half (control) looked at colored prints. For the recognition test, the words of the first list were mixed with the words of Lund's second and third lists.

(*b*) *Method of Recall* vs. *Method of Relearning.* A few investigators have called especial attention to the difference in their results when scoring was by the method of recall and when it was by the method of relearning (sometimes presented in terms of saving).[53] Thus, in Cheng's (16) study of the factor of similarity, he concluded that, with measures in terms of recall, retroactive inhibition increases at first and then decreases as similarity increases from no similarity to approximate identity, whereas, with measurements by the saving method, there was no consistency in the results.

McGeoch (65), in his study of the degree of original learning, found that retroactive inhibition decreased as learning increased, but that the amount of the decrease was a function of the method, recall being much more susceptible to inhibition than the method of saving.[54] With regard to practice effects, when the frequency of the *original* lists was varied, there was a marked decrease in retroaction from the first to the second cycle when measured in terms of recall, but, in terms of relearning, there was almost no decrease. On the other hand, in his subsequent study (71), where the frequency of the *interpolated* lists was varied, the influence of practice was very decided in relearning but almost absent in the case of recall.[55]

The findings of McGeoch (65) are corroborated by those of Lester (56) and of Johnson (54), both of whom found retroactive effects to be greater when measured by recall than when measured by relearning scores.

Another dichotomy was reported by Bunch and Wientge (14), who found that, in terms of relearning and recall scores, indifferent material was more susceptible to retroactive inhibition than unpleasant material, but that, in terms of per cent saving scores, unpleasant material was the more susceptible.

V. Summary of Conclusions Based on Experimental Data

The conclusions from the various investigations are stated below and are numbered to correspond with the variables considered above. Particular attention is called to the fact that these conclusions are *not necessarily final* on any one point, but are only indicative of the trends which the experimental data have suggested.

[53] *Cf.* Bean (4).

[54] Also, McGeoch (67).

[55] Other differences in results according to the method of measurement were noted by McGeoch in another study (73); see section (3) above, *The Time Interval.*

Also, the differences between McGeoch and McKinney's results with poetry (79) and with prose (80) are probably "in large part a function of the method of recall" (80).

(1) As to the degree of similarity between the original activity and the interpolated activity, Skaggs (116) has perhaps given a close approximation of the general relationship: "Other factors being constant, there is a certain admixture of like and unlike elements of method or content which will result in a maximum amount of retroaction. With a decrease in the common elements retroaction will decrease, finally reaching a minimum. With an increase in common elements retroaction will decrease, reaching zero with identical elements."

The present writer would state the *general* relationship as follows: At the maximum of dissimilarity (in content, meaning, form, method, operation, environment, etc.) between the two activities, retroactive inhibition may occur. As the degree of similarity of one or all of these factors is relatively increased, the degree of retroactive inhibition also tends to increase. A certain point is eventually reached, however, after which increasing the degree of similarity results in more and more *actual identity* of the various factors (content, meaning, form, method, operation, environment, etc.); and from this point on, *i.e.*, identity of one or more factors, the amount of retroaction tends to decrease, until at the upper limit, actual identity of all the factors, there may be no inhibition at all but simply repetition.

(2) Retroactive inhibition may occur when the interpolated activity is introduced immediately after original learning, or when it is not introduced until several hours, days, or weeks afterward. Evidence of retroaction has been demonstrated in such extremes as: interpolation immediately after learning and immediately before recall; interpolation immediately after learning but previous to a time interval before recall; interpolation some interval of time after learning and previous to another interval before recall; interpolation some time interval after learning and immediately before recall. Although some investigations have suggested that the earlier the interpolated activity is introduced after original learning, the greater is the amount of retroactive inhibition, other experiments have indicated that the temporal position of interpolation is not an important condition of the amount of retroaction.

(3) With lists of adjectives for learning material, no consistent variation in amount of retroaction with time interval has been demonstrated. In the case of poetry and of prose, however, there are indications of greater amounts of retroaction after 7 days than after 15 minutes.

(4) Susceptibility to retroaction tends to decrease as the amount of material for the *original* activity is increased; there is perhaps a lower limit of this tendency.

(5) (*a*) In general, the greater the degree of learning of the *original* activity, the less susceptible is the learning to retroactive inhibition. (*b*) It is possible that some amount of overlearning of the *original* activity tends to decrease susceptibility to retroactive inhibition.

(6) It is possible that susceptibility to retroaction tends to increase as the amount of material for the *interpolated* activity is increased.

(7) The amount of retroaction tends to increase with the degree of learning of the *interpolated* activity, although not proportionately, provided the interpolated learning is not too great. After the interpolated activity has been learned to a certain degree (possibly to about the same degree as the original activity), additional increments of interpolated learning seem to have little effect on the amount of retroaction.

(8) Practice or previous experience with the original learning material or with the experimental conditions under which retroactive inhibition is being measured is probably associated with less susceptibility to inhibition.

(9) Perhaps susceptibility to retroactive inhibition varies with the time of day, being greater in the evening than in the morning, or perhaps it varies only with the greater fatigue of the subject.

(10) When a period of 4 hours or of 8 hours of sleep, rather than an equal period of waking, intervenes between learning and recall of nonsense syllables, the differences in amounts of retention favor sleep over waking. There may also be differences in retention in favor of sleep for one-hour and two-hour periods. The advantage of sleep is probably not as great at 4 hours as at 8 hours.

(11) (*a*) "The arousal of an apperceptive set" immediately before original learning perhaps exerts a detrimental influence on recall, especially if the "set" is "congruous" to the learning material. On the other hand, a set or attitude at the time of learning developed by instructions to make an effort to avoid the interference effects of the interpolated activity reduces the amount of retroactive inhibition. There is some tendency for increasing amounts of information as to the activities of the experiment, given at the time of original learning, to be associated with decreasing amounts of retroaction.

(*b*) There is some evidence that original learning in a waking state and interpolated learning in a hypnotic trance, or original learning in a hypnotic trance and interpolated learning in a waking state, result in more interference in recall than when both original and interpolated learning are in the same state. There is also some evidence that, when both original learning and interpolated activity have occurred during waking, hypnosis for the retention test does not materially affect the amount of retroaction.

(*c*) Attempts to decrease susceptibility to retroactive inhibition by the direct suggestion that the original material will be remembered well, and to increase susceptibility by the direct suggestion that it will *not* be remembered well, have not proved successful.

(12) (*a*) Both verbal and motor materials are subject to retroactive inhibition. (*b*) Both sense and "nonsense" materials are subject to retroactive inhibition. (*c*) Meaningful (interrelated) material is subject to retroactive inhibition. It may be that prose is less susceptible to retroaction than poetry. (*d*) Pleasant learning material is less subject to retroactive inhibition by indifferent material than is either indifferent or unpleasant learning material. The evidence is conflicting as to whether indifferent or unpleasant learning material is the more susceptible to interference effects.

(13) (*a*) As compared with normal learning, electric shock during *original* learning apparently decreases the amount of retroactive inhibition. (*b*) 1. There is slight evidence in the case of human subjects which might suggest that certain types of emotional or sensory disturbance during *original* learning may be associated with retroactive inhibition, but that comparatively small disturbances may show little or no inhibition. There is some evidence that learning under conditions of a small amount of caffeine reduces susceptibility to retroactive interference. 2. It has not yet been shown whether or not susceptibility of animals to retroactive inhibition is influenced by cortical damage.

(14) (*a*) As compared with normal learning, electric shock during *interpolated* learning apparently decreases the amount of retroactive inhibition. The interpolation of shock alone, not associated with a learning activity, may have a slightly detrimental effect on retention, but this is not true with all individuals.

(*b*) 1. With human subjects, emotional reactions or sensory disturbances *interpolated* between learning and recall may increase or may decrease the amount of retention, depending upon the particular experimental situation. In general, it may be true that interpolation

of pleasant affective value increases retention, whereas interpolation of unpleasant affective value decreases retention. 2. Immobilization produced by cold has been shown to interfere with the retention by cockroaches of a previously learned habit. As to whether or not experimentally induced inactivity of bees interferes with retention may depend upon other variables.

(15) Under certain conditions, the relationship may be an inverse one between the amount of retroaction and the amount of positive transfer from the original to the interpolated activity.

(16) The phenomenon of retroactive inhibition within a series has been demonstrated.

(17) (*a*) Learning by adults is subject to retroactive inhibition. Individual differences in susceptibility have been found, but no consistent sex differences. (*b*) Learning by children is also subject to retroactive inhibition. There is apparently no increase or decrease of susceptibility with age. (*c*) The results of certain experiments with rats as subjects have shown evidence of retroaction, whereas others have not. (*d*) Learning by cockroaches and by bees is subject to interference effects under certain experimental conditions.

(18) (*a*) Although certain investigators have denied the possibility, retroactive inhibition has been experimentally demonstrated when retention is measured by the method of recognition. (*b*) Retroactive effects are apparently greater when measured by recall scores than when measured by relearning scores.

VI. Theories of Retroactive Inhibition

(1) *The Three Theories Which Have Been Offered to Account for Retroactive Inhibition.* (*a*) *The Perseveration Theory (Müller and Pilzecker).* According to the perseveration theory of Müller and Pilzecker (**89**), learning is followed by a period of gradually diminishing activity of certain neural processes which serve to intensify the associations established in the learning. The perseveration tendency is considered to be a kind of after-discharge—a continued activity—of the neural elements following any kind of learning activity. This after-discharge is of the utmost importance in the "setting-in" of the memory pattern. The introduction of any kind of strenuous mental activity while this setting-in is still in progress will interfere to some extent with the continuation of the setting-in process. This means that inhibition is due to the interference offered by interpolated activity to the perseveration or setting-in of the original activity. Consequently, memorized material is not retained

as well when memorizing is followed by mental work as when it is followed by comparative rest. As the after-activity of the neural elements gradually diminishes, the detrimental effects of interpolated work will vary inversely as the time elapsing between the end of memorizing and the beginning of the work. In other words, the sooner the second activity is engaged in after the first, the greater is the retroactive effect. There is also an implication in the theory that the amount of retroaction varies with the intensity of the interpolated activity rather than with the degree of similarity to the original activity.

(*b*) *The Transfer Theory (DeCamp).* The perseveration hypothesis has been criticized by DeCamp (**21**), who offers a theory in terms of transfer of training. His theory is like the perseveration theory in that the primary cause of the inhibition is considered to be due to interference with the setting-in process by some activity, but the perseveration theory is extended to take into account the similarity factor. The inhibition is considered to be a function of the relative identity of the neurological elements of the original material and of the interpolated material, and not a function of the difficulty of the interpolated material. DeCamp states his theory as follows:

> "From the neurological standpoint, in the learning of a series of syllables, we may assume that a certain group of synapses, nerve cells, nerve paths, centres, etc., are involved. Immediately after the learning process the after-discharge continues for a short time, tending to set the associations between the just learned syllables. Any mental activity engaged in during this after-discharge, involving or partially involving the same neurological groups, tends, more or less, to block the after-discharge, and gives rise to retroactive inhibition. Engagement in any mental activity, involving a new—so far as it is new—group of synapses, neurones, etc., would allow the setting process of the just excited group to proceed unhindered. The effect of retroactive inhibition would vary directly as the relative identity of the neurological groups concerned. . . . We should expect retroactive inhibition to appear more readily where material similar to that learned is used for the interpolated work."

In other words, the greater the similarity of the interpolated activity to the original activity, the greater the inhibition. There is also the implication, as in the perseveration theory, that the second activity should be introduced almost immediately after the first—during the "after-discharge"—in order to produce retroactive inhibition.

(*c*) *The Transfer Hypothesis and Disruption Hypothesis (Webb).* Webb (**134**) offers a theory of retroactive inhibition stated more purely in terms of transfer of training without reference to persevera-

tion. He suggests that retroaction may be the result of simple transference of certain elements of the interpolated activity to the relearning of the original activity; this transference may operate either advantageously or detrimentally. He develops a second theory which he terms the "disruption hypothesis". According to this view, certain elements of the original activity are transferred to and used in the interpolated activity. Consequently, this incorporation of certain elements of the original activity into the subsequently acquired activity involves a partial disruption and disorganization of the original activity. The component elements of the original activity have already been welded and associated into a unitary whole. The utilization now of certain elements of the original activity in a new situation must necessarily involve their dissociation from their former contextual relationship, and, in this way, the activity must be partially disrupted and disorganized. Webb points out that these two hypotheses are not antagonistic, but rather that they supplement each other. The effect of the interpolated activity upon the relearning of the original activity may be due in part to the process of disruption, and it may be due in part to the transference of certain components of the interpolated activity which are carried over to the later relearning of the original activity. Consequently, retroactive inhibition may be caused by the disruption of parts of the original activity by the interpolated activity, and also by the transfer of parts of the interpolated activity to the relearning of the original activity.

(2) *Views of Other Investigators.* (*a*) *Skaggs.* Skaggs "feels that the perseveration notion advanced by Müller and Pilzecker is our best hypothesis" (114).[56] However, the hypothesis of retroactive inhibition which Skaggs advocates is defined in a very strict sense, for he rules out any case of inhibition due to the degree-of-similarity factor and holds that this is "reproductive inhibibition" (116). His hypothesis as to retroactive inhibition involves two assumptions. The first assumption is "that there is a perseveration of the biochemical processes in neurones and synapses even after the original stimulus is removed. We assume that this continued process is very important for the fixation of the absolute impressions and the bonds of association. If this process is interfered with in

[56] White (135) says: "In the case of the fifteen subjects who were hindered by the electrical stimulus, the explanation must lie in those factors which explain retroactive inhibition, such as breaking of set, as indicated by Mueller and Pilzecker." Van Ormer (128, 129) believes that inhibition of a perseveration process following learning is an important factor in forgetting.

any way, the strength of the associative bonds will not be so great as otherwise"(116). The second assumption is: "Any intense activity occurring in the brain, at about the same time or shortly after a preceding neural process, will tend to drain the energy from the neurones which were originally excited. This is merely the application of the McDougall drainage theory"(116).

Skaggs (117) has recently indicated that the perseveration view may not be of any great significance beyond a few hours after learning. He says: ". . . There are two factors causing what is now called retroactive inhibitory effects. In one case a strong mental-neural activity cuts in and disorganizes an on-going mental-neural process, a process of neural inertia. This is true retroactive inhibition since a *second* activity interferes with a fixing process on the part of an *earlier initiated activity*. There is considerable (at least indirect) evidence for such fixating processes.

"In the other case there is the matter of the establishment of wrong associative tendencies *which operate at the time of recall*. This is due to the mixture of like and unlike elements in the two learning situations. Whether we wish to call the detrimental influence on later recall *retroactive inhibition* or *plain reproductive inhibition* depends entirely on whether the original learning is actually weakened as such at the time of the interpolated activity or whether it is a matter of confusion and blocking in the actual recall. Perhaps the point is drawn entirely too fine and no decision can ever be made."

(*b*) *Robinson.* A transfer theory is favored by Robinson (103).[87] He says: "One must admit that it would be stretching a point to accept the transfer theory, if all similarity were, like the superficially most evident sort, a matter of contents, and if all transfer were a matter of elements active in original memorizing being active, and therefore getting new associative potentialities during interpolation. There is no need, however, for so limiting one's conceptions of similarity and transfer." He goes on to say that his own experiments show "the effectiveness of other kinds of similarity than that of content". Transfer is not so restricted a phenomenon as is often supposed. For example, the transfer which causes retroaction may in one instance be a transfer from memorizing to interpolation, while

[87] Whitely (137) and Bunch and McTeer (13) have interpreted their results as being explicable in terms of transfer but not in terms of perseveration. Lester (56) believes that the perseveration theory, although not precluded, is highly improbable as an explanation of her results, but that the similarity factor is of importance. Johnson (54) has interpreted her data in terms of a transfer theory. Also, *cf.* below, section (*c*), *McGeoch.*

in another it may be a transfer from interpolation to recall. This particular phase of Robinson's theory as to transfer is more in accord with Webb's ideas than with those of DeCamp. He says that, in order to explain retroactive inhibition in terms of transfer, it is simply necessary to assume "that the situations, memorizing, interpolation, and recall, have enough in common, through content, form, process, or even temporal contiguity, to insure the reinstatement of a part of one of the situations in intimate connection with another."

(*c*) *McGeoch.* Since the view of Müller and Pilzecker suggests that retroaction varies with the intensity of the interpolated activity rather than with its similarity to the original activity, McGeoch (**69**) tested the influence of the interpolation of learning and of relatively intense non-learning activities (tapping, reading plus shock, and color naming) upon retention. Interpreting his results as unfavorable to the perseveration theory and in support of a transfer theory,[88] he states that the inhibition was due to a confusion between the items of the original and interpolated activities, or from a blocking by the latter of the former.

In considering certain results from another study, McGeoch says (**73**): "If perseveration is blocked by interpolated learning, the antecedent activity which is, thus, denied the fixating effect must be assumed to start its course through time, under most conditions of original learning, with a less well-fixed organization than does the material which was followed by rest. If no other factors than those implied by the perseveration theory are present, either the curves of retention might be parallel while percentages of difference increase or the percentage differences might not vary. . . . Since the perseveration theory is indeterminate with respect to the point at issue, we may turn to the transfer theory, by which the facts of these experiments are better interpreted." He then considers three possibilities of the transfer theory as to "the temporal locus of the confusion which is supposed to follow from the transfer between original and interpolated lists": (1) that the transfer and resulting inhibition may occur during the interpolated learning; (2) "that the action of the interpolated activity is distributed in some manner over a part or all of the interval"; (3) that "the temporal locus of negative transfer is during the measurement of retention". In the light of experimental data, as to the relation of temporal point of interpolation and of length of interval to amount of retroaction, the third possibility seems the most acceptable to McGeoch.

[88] McGeoch and McDonald (**78**) interpret their results similarly.

For example, he found "relative constancy of degree of inhibition over intervals varying from 20 min. to a week" (73). Also, he has shown "that the positions of interpolation immediately subsequent to learning and just prior to relearning may occasionally be equal in percentage of retroaction produced, but that the position just before relearning often produces the greater inhibition. There is clearly no evidence for the superior potency of the position immediately after learning. The prediction from the perseveration theory that immediately interpolated activity should block perseveration and thus produce inhibition more strongly than should later interpolations is directly contradicted. Either the prediction does not follow from the theory or the failure of the facts to conform to the prediction must weigh against the theory" (74).

He points out, however, that comparisons of positions of interpolation cannot be expected to yield "crucial evidence" against the perseveration theory (74): "When interpolation occurs immediately subsequent to original learning, the organization of the latter is at its maximum during the interpolation. When, on the other hand, interpolation is delayed until the period immediately before relearning, forgetting of the original material has had an opportunity to occur and the interpolated learning finds the original activity less well organized. The degrees of interpolated learning are equal in the two cases but those of the original material are not, and the experiment thus becomes one to measure the effect of equal interpolation with two degrees of organization of the original activity" (74). Yet, since there is nothing in the usual statement of the transfer theory "which would lead one to expect more inhibition from one position of interpolation than from another", this theory is supported (74). Other work on the temporal point of interpolation also "has an indirectly positive implication for the transfer theory, but whether it is crucial evidence against the perseveration theory is questioned" (81).

In a later experiment (79), however, McGeoch and McKinney found that nonsense syllables were as potent to inhibit the recall of poetry as was more poetry of the same kind,[89] and that this was difficult to interpret by the transfer theory, "since, if transfer is at the basis of retroaction, similarity and inhibition should, over a wide range, be positively correlated. . . . It may be that relative degrees of organization of the original and interpolated materials are very important in determining amount of retroactive inhibition and that,

[89] They also found that nonsense syllables were nearly as potent to inhibit prose as was more prose of the same kind (80).

when both materials possess a fairly high degree of internal organization, as is probably the case when both are sections of poetry, retroaction is, other things being equal, at a minimum. It may be, further, that a low degree of organization in the interpolated material, for example, permits a more ready confusion between it and the original material and hence a greater amount of inhibition. That is, degrees of organization may constitute a factor coördinate with similarity in an interpretation of the transfer theory."

McGeoch and McKinney then add (79): "On the other hand, the perseveration theory is favored by this result. It is an essential part of this theory that the important condition of retroactive inhibition is the diminution or complete blocking of perseveration by the interpolated activity. The crucial aspect of this activity should be its intensity, while its similarity to the original activity should be inconsequential. According to this theory, therefore, the interpolated learning of nonsense syllables might be expected to exercise an inhibitory effect fully comparable to that produced by the interpolated learning of poetry. It is believed, however, that before this apparent contradiction of the transfer theory and support of perseveration may be given adequate evaluation, both theories, and more particularly the transfer theory, must be more carefully analyzed." [60]

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[60] It has been suggested by Purdy (99) "that normal forgetting depends not on the mere occurrence of new activities as such, but rather on the occurrence of new activities which themselves leave *after-effects* or traces. Forgetting (in other words, retroactive inhibition) is not due to an immediate influence of a present activity upon a memory-trace, but to a later interaction between one trace and another."

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BOOK REVIEWS

CHANDLER, A. R. *Beauty and Human Nature.* New York: D. Appleton-Century Company, 1934. Pp. ix+381.

Professor Chandler has attempted what many would have considered the impossible—to write a treatise that would embrace both the philosophical and psychological phases of aesthetics. Kate Gordon made a rather successful attempt at such a survey in a text which appeared back in 1909, but in those days the fields could be more easily surveyed. Since that date, portions of the field have been covered by Pratt, Valentine, and others, but no general survey of experimental aesthetics has until now appeared. To pave the way for his proposed text in this field, Chandler in 1933 issued *A Bibliography of Experimental Aesthetics 1865–1933.*

In the reviewer's opinion Chandler has done a splendid job with the present work. His sins appear to be almost entirely those of omission. His evaluations of earlier experiments and present German studies are particularly good; his treatment of current experiments is a bit less thorough. Although he mentions practically all lines of research, the psychologist will probably feel that a somewhat less extended treatment of the older experiments and the inclusion of more of the modern data would have made for a better balance. One extremely important line of aesthetic research which is not even mentioned is that which Robinson has supervised on the behavior of museum visitors.

In a day of rather careless editing the book is singularly free from errors. The author quite obviously knows the field of philosophical aesthetics. It is made obvious to the reader that Chandler has traveled extensively through the more important art galleries of the Occident. That he had the teacher of aesthetics in mind is clear from the fact that his chapter bibliographies contain titles and notices of easily available works, especially those which contain cuts illustrating the problems under discussion. While the text itself contains no pictures, there are to be found numerous tables, poems, and snatches of music.

The book opens with a chapter on "Art, Beauty, and Experience" and a second on "Varieties of Aesthetic Experience." Although the author is writing here more as a philosopher than as a psychologist, few of the latter camp will find much with which to quarrel. Those

who have come to expect all books on aesthetics to open with armchair speculations too removed from science ever to be checked or even to be played with will be agreeably surprised at the small amount of such philosophizing in Chandler's introductory chapters. It is true that he does follow McDougall to the rather ludicrous point of linking the beauty of Venetian glass to man's protective impulse, but after this chapter McDougall is not again employed as a prop.

Chapters on the pleasantness and expressiveness of visual forms follow. These are especially notable for the thoroughness with which Chandler reviews the early studies in this field. The closely allied topic of color is treated at considerable length, von Allesch's experiments being given more attention and rated more highly than they deserve—at least this is the reviewer's opinion. The chapters on architecture and sculpture receive rather a philosophical than a psychological treatment. This was to have been expected, as psychologists have avoided work on these topics. Pictorial art is next considered.

Chandler's consideration of musical aesthetics is to be found in three chapters—on elements, structure, and expressiveness. Of these, the one on structure is perhaps the most interestingly handled, although its section on consonance reflects the unsettled state of opinion in that field. To the reviewer's mind the theory that consonance depends upon the simplicity of ratios is presented in too narrow a form. Chandler makes mention of the point that the minor seventh, according to most criteria of consonance, is more consonant than the major seventh, although its ratio, 16/9, is more complex than that of the latter, 15/8. It *is* more complex, to be sure, in its unaltered form, but if Max Meyer's theories are followed—and the reviewer does not follow them on this point—the 16/9 ratio is reduced to 1/9 and the 15/8 to 15/1, procedures which make the major seventh the more complex. Since Chandler's text went to press, E. G. Bugg (*Psychol. Monog.*, 1933, **45**, No. 2), has issued a study in which he states that consonance "is a complex perceptual phenomenon which cannot be adequately accounted for or profitably investigated on the basis of any of the traditional, oversimplified hypotheses"—a conclusion to which the reviewer most heartily subscribes.

Following the discussion of music are two chapters devoted to language. To the psychologist the portions of greatest interest will probably prove to be those dealing with E. W. Scripture's studies reported in German in 1928 and 1929.

In the section entitled "Talent and Genius" the author wisely

keeps to the middle of the road both with the nature-nurture and the normality-abnormality issues. He recognizes that Watsonian psychology, behaviorism, and environmentalism are not synonymous terms, a point not yet understood by many fairly prominent psychologists. His attitude on tests follows that of Pratt, who has maintained that such measures possess negative rather than positive diagnostic value. The closely allied topic, "The Artist and His Work" is discussed under several headings such as the "endowment and development of the artist", "stocking the mind", "unconscious reorganization of material", "inspiration", and the like.

In the last chapter, that on "Culture and Appreciation", Chandler makes it clear that he is a believer in relative standards in art. He does concede, however, that it is possible to look upon the arts as expressing higher or lower levels of complexity and subtlety. The higher levels can be achieved, *i.e.*, appreciation can be cultivated, in "three main ways: contact with graded series of works of art, practice in artistic production or expression, and direct or indirect contact with persons who appreciate the arts". . . . "Critics have no absolute authority, but they have a relative authority in proportion to the breadth of their experience in a given art, the delicacy of their discrimination, and the sanity of their views on the place of art in life." The book closes with an interesting section on "Aesthetic Appreciation and Other Values".

Beauty and Human Nature should serve a dual purpose—as a textbook and as a reference work for all who profess an interest in the arts. Its reasoning is simple enough that an intelligent layman can find in it much of interest.

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KLINEBERG, OTTO. *Negro Intelligence and Selective Migration.* New York: Columbia University Press, 1935. Pp. xii+66.

Two theories have been advanced in explanation of the superiority of northern over southern negroes on mental tests. According to one view, relatively superior negroes tend to migrate from the South. The alternative hypothesis holds that the better environment of the northern negro—especially the better educational facilities—produces an improved mental level. Klineberg correctly observes in this monograph that this problem cannot be solved by "arguments of a purely logical nature". He reports results of several studies designed to check the hypothesis of selective migration and concludes from them

that the theory is untenable. Two methods were employed: (1) comparisons of school grades of migrant and non-migrant children in Birmingham, Nashville, and Charleston; (2) comparisons of "intelligence test" scores of northern-born with southern-born negroes differing in length of residence in New York.

The results of the grade comparisons are not consistent. In Birmingham, the grades of migrant children were below the average for the negro school population, while in Nashville and in Charleston the migrants were above average. None of the differences is great. Klineberg suggests two possible explanations for the discrepancy: (1) that economic conditions are more favorable to the negro in Birmingham, with the result that the more intelligent negroes tend to stay there, whereas in the other two cities less favorable economic conditions cause the more intelligent negroes to migrate; (2) that selection has become increasingly severe in recent years and that the Birmingham results were based upon an earlier period than those for Nashville and Charleston. Klineberg concludes that "the school records examined give no evidence that negro migrants to the north are superior to the non-migrants". This statement is difficult to reconcile with his assumption of a gradual improvement in the intellectual level of the migrants from 1915 to 1930.

The study of the relation between psychological test scores and length of residence in the North involved the examination of 3,081 ten- and twelve-year-old negro children in New York city schools. The following tests were used: National Intelligence Test (three studies); the Stanford-Binet scale (three studies); the Otis Self-Administering Test (one study); Minnesota Paper Form Board and the Courtis Arithmetic Tests (one study); six tests of the Pintner-Paterson Performance scale and a speed of movement test (one study). Klineberg reports the results simply in terms of average scores for varying years of residence in the North. Measures of variability are given for most of these averages, but in two of the Binet test studies the standard deviations are unaccountably omitted. Klineberg concludes that as far as the results presented go, a definite superiority of northern over southern negroes is established, and that this superiority is "due to factors in the environment, and not to selective migration" (p. 59). This rather sweeping generalization does not receive unequivocal support from the data. Even if one grants—which the writer is unprepared to do—that the techniques and samplings are adequate to a final solution of the problem, the specific figures are not as conclusive as Klineberg implies in his sum-

mary. A definite relation between test scores and length of residence exists in the case of two of the National Intelligence Test studies, but only imperfectly in the third. One of the Binet studies yielded a very good correlation between score and length of residence, but the other two showed only slight and unreliable differences between southern and northern-born children. Despite this fact, Klineberg holds that the Binet test results are more conclusive than the group test data in their reflection of an environmental effect! As regards the performance tests—including the speed tests and the arithmetic test—he remarks that results secured with them "failed to demonstrate any definite environmental effect". Actually then, the results in less than half of the nine studies conform to the author's general conclusion.

In the reviewer's opinion, work of this sort raises problems, but is not likely to solve them. He feels that he can make this statement with propriety, since it applies to his own work in this field. A really definitive study of the causes and effects of migration is a problem entirely beyond the scope of the individual investigator. Only a protracted national program with substantial financial support can be expected to yield unequivocal results. Similarly, the question of the extent to which environmental opportunities can equalize the abilities of whites and negroes will probably be answered only when a special foundation for the investigation of this problem is established. The careful organization of experimental schools, or homes for negro children, in this country and in Africa, equipped to train and study negro children from infancy to maturity, might eventually produce valid scientific results on this problem. Psychometric studies of small samplings in a few areas are of negligible import.

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SANDERS, BARKEV S. *Environment and Growth.* Baltimore: Warwick and York, 1934. Pp. xviii+375.

The book here under review ends with this paragraph: "The study does not dispute the fact that in all probability there are inherent differences between the various socio-economic classes. Its one and only contention is that the rôle of environment cannot be overlooked in view of the evidence that differences found in children of different socio-economic classes are of environmental origin and, if environmental differences are important enough to affect physical growth, it is most probable that they affect psycho-social adaptations

and behavior as well." With this final statement no student of human development would quarrel, and no new book is needed to set it forth. The conclusion is widely embodied in standard texts of biology, psychology, and sociology.

Why then do we have this book? The primary reason for writing it was not to convey as an end result this final paragraph (which is as a matter of fact somewhat at variance in tone with the book as a whole), but to prove to the writer and to his readers that environment really is a more potent determiner of development than heredity. "To simplify the problem" consideration was stated at the outset to be about to be limited to studies of stature and weight, but other variables ultimately become quite essentially involved in the discussion.

A large amount of literature, from early to most recent dates, and in various languages, is brought to attention, as will be evident from the fact that the bibliography in fine print covers sixty-five pages. This is a valuable feature of the work, representing much diligent labor. However, the interpretation of this accumulated literature leaves much to be desired in the way of critical insight and cogency. The author is constantly delivered from these controls by a bias in favor of his faith in the potency of environment to determine the course of development, and by a hope that acquired characteristics will be proved to be heritable. He holds firmly with these twin articles of faith, upon abandonment of which so much of current effort at human betterment would necessarily undergo immediate radical redirection.

The avowed and at the same time disavowed bias of the book comes out in various ways. For instance, in discussing the researches of McDougall, carried out to determine the possible effects, in the case of tank rats, of specific education upon the capacity to learn of subsequent generations, the author fails to cite the literature of criticism which bears upon McDougall's results. In fact, the author is throughout inadequately critical of data, tending as he does to interpret concomitants as causes. To illustrate, from the data showing that neonates born of mothers who rested during pregnancy are larger than in the case of non-resting mothers, the author is inclined to say that *rest* was the causal factor in producing size, regardless of the fact that mothers who rest are almost certainly differently selected from mothers who do not, in such a way that organisms of different quality are involved in the comparison.

Also, correlational studies made with groups homogeneous in

respect to one of the variables being studied are accepted as establishing degrees of interdependence equally valid with those established by use of relatively unrestricted range of the variables involved. Concomitants varying together, such as intelligence and socio-economic status, are thought to prove that good food produces or tends to produce intelligence of a high order; and this interpretation is further favored, in the mind of the author, by the accumulated studies which show stature and weight to vary concomitantly with intelligence. "In order to indicate that environmental differences ordinarily found among the socio-economic classes are sufficient to retard or accelerate growth, data showing the importance of environment on ontogenetic growth and development are based on evidence of the differential growth in these classes" (although the socio-economic differences may be, and probably are, merely the outcome of original differences in quality of the organisms compared).

Flaws in English, to which the book is unfortunately subject, chance to be exemplified in the quotations given. Misprints are also somewhat frequent in the bibliography.

It may be well for purposes of stimulation to put forth argumentative works like that here reviewed. However, in the absence of crucial studies, difficult to execute, planned from the beginning to show cause and effect in the developmental process, this book adds, and can add, nothing to current knowledge or thought. Accumulated studies are sufficient to establish that desirable traits are concomitant with desirable conditions, and sufficient for nothing else. What is cause and what is effect we do not know, and this book does not inform us.

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ALLEN, RICHARD D. *Self-Measurement Projects in Group Guidance.* Vol. III, Inor Group Guidance Series. New York: Inor Publishing Company, 1934. Pp. xvii+274.

This book, as designated in its subtitle, is a teachers' manual for "a laboratory course for pupils in the study of individual differences". In the introduction, Dr. Ben D. Wood sets forth briefly the concept that guidance is a philosophy, and not a dull bookkeeping. When this is fully recognized "curriculum making will become a process of formulating individual goals, and of modifying them progressively in accord with the developing capacities, interests, and needs of individual children". To attempt to make this concept of

guidance more vivid to teachers and administrators, Dr. Allen has prepared this manual.

The first sixteen pages of the book are devoted to a general discussion of the purpose of the projects, self-measurement as a group-guidance technique, advantages of the self-measurement projects to the counselors, and an outline of the method of procedure. The devices proposed for eliminating the fear attitudes of pupils toward tests are: (1) to give tests at the beginning rather than at the end of the term, to discover the instructional needs of individual pupils and of the class as a whole; (2) to provide that the test results may raise a pupil's mark but will not lower it. Further emphasis is given to the point suggested in all projects that no one except the pupil himself should know his score. He should be able, in addition, to compare himself objectively with the class. By these means the author hopes to develop in the pupils an attitude of "guidance readiness".

Of the 63 self-measurement projects outlined in the remainder of the book for use with junior and senior high-school pupils, 12 are concerned with tests of skill subjects and background, 15 with tests of secondary school subjects, 14 with the measurement of interests, information, and adjustment, 13 with tests of special abilities and aptitudes, and 9 with tests of personality and attitudes. Each is considered in terms of (1) preparation of the counselor for carrying out the projects, (2) suggestions for motivating the pupils to take the tests, (3) administration of the tests, (4) issues and implications, and (5) possible by-products of the project.

At the end of the book are given sample charts, tables and graphs, a high-school class survey questionnaire, a bibliography of books which "should be in the library of any school in which a group-guidance course contains self-measurement projects", a bibliography of tests, and a cross index to the three volumes in the group-guidance series in which the book under consideration is Volume III.

This book sets a high standard but misses the mark. It begins with an emphasis upon a scientific approach to problems of individual differences, but throughout the projects practically no assistance is given to the counselor in the evaluation of the individual tests. To be sure, he is warned continuously to study the manuals of directions for administering the tests and interpreting the results. But anyone who has worked extensively with these manuals appreciates fully their inadequacy from the standpoint of the "scientific approach". Altogether too often they are sales manuals. The counselor needs, in

addition, some guide which brings together and evaluates the evidence that has accumulated for each test to be used in a self-measurement project. When such a critical analysis is made, the limitations of many of the tests recommended will be much more clearly expressed. As examples, one might cite the test of "Fundamental Abilities of Visual Arts" used in Project 27, "The Adjustment Questionnaire" in Project 39, the test of "Musical Talent" in Project 43, and the "Social Intelligence" test in Project 45.

Much needless repetition appears in the outlines of the projects. If the general outline at the beginning had been made more complete, the space consumed by the repetition could have been used more profitably by supplying the counselor with an evaluation of each test recommended. In addition, data such as the cost per copy of each test, and the cost for scoring the Strong Interest Blank would have made the book more serviceable.

In spite of the criticisms that have been raised, the manual is useful. It is unique in its conception to provide self-measurement exercises for high school pupils. The general attitude expressed toward tests in the guidance program is conservatively wholesome and many of the specific suggestions for conducting the experiments are excellent. The book should aid many teachers, administrators, and counselors, and if used critically, will provide stimulating self-measurement exercises for the pupils.

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McCARTHY, RAPHAEL C. *Training the Adolescent.* New York: The Bruce Pub. Company, 1934. Pp. xx+298.

If the title of this book had been expanded into the Training of the Adolescent in the Roman Catholic Religion, it would have been much more definitely representative of the content and of the author's intent. This is important, because it makes the book stand in a class by itself, so far as the reviewer knows. It is neither a systematic presentation of the psychology of adolescence nor a general treatise on religious and moral education, although much of each is necessarily involved. It is essentially a manual for the instruction and guidance of Roman Catholic parents and teachers. Because of this the author sometimes assumes a knowledge of the vocabulary and practices of his church which may make the text somewhat difficult for non-Catholic readers. The presentation of the psychology of adolescence is in general good and covers the usual topics. That it

varies much in its adequacy may be due to the preference for emphasis upon the philosophical and religious implications and relations, but it does vary greatly in adequacy. Sometimes it seems unwisely superficial. Stealing is presented without any consideration of the inductive studies of recent years or analyses of motivation; sex differences are presented in a paragraph with only the old notion of one sex being the complement of the other; the psychology of the gang is presented without consideration of Thrasher's illuminating work; attitudes are discussed but the Chicago and Columbia studies of attitudes are ignored; the psychoanalytic theory of religion is discussed but DeSanctis' work in this field (himself a Roman Catholic) is not mentioned. The style conveys the impression of certainty, even an air of finality, which the material, to those who know the available sources, does not always justify. Readers familiar with physiological experimentation will be surprised to read that "dogs from which the spinal cord has been removed become angry on being shown a cat". There is a good bibliography of suggested reading, but authenticating references are few In spite of these deficiencies, the book will no doubt be of considerable service in Roman Catholic circles where religion and moral education are the chief items of emphasis and instruction.

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CORRECTION

In the article on "Forty Years of Psychology" (PSYCHOL. BULL., 1934, 31, 533–559) the subdivision of English publications into *American* and *British* was inadequate. Many British publications were inadvertently classified as American. Although the figures included under *American* and *British* may be sufficiently representative of the trend of publications in America and Britain, the numbers of the two subdivisions in the various tables are inaccurate. The actual numbers of British publications are considerably larger than those given in the tables, and the numbers of American publications are correspondingly smaller. The reader is urged to consider only the data concerning the total number of publications in English and to disregard the separate figures for American and British publications.

The author is indebted to Dr. Mary Collins, collaborating editor of the *Psychological Index,* for calling attention to this matter.

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